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ENVIRONMENTAL QUALITY

HANDBOOK FOR ENVIRONMENTAL IMPACT ANALYSIS

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DEPARTMENT OF THE ARMY

HANDBOOK FOR

ENVIRONMENTAL IMPACT ANALYSIS

SUMMARY

This handbook presents recommended procedures for use by Army personnel in the preparation and processing of environmental impact assessments (EIA) and statements (EIS). The procedures outline in step-by-step fashion the progressive actions necessary to satisfy the requirements of the National Environmental Policy Act of 1969 and the subsequent guidelines issued by the President's Council on Environmental Quality (CEQ) charging all federal agencies to utilize a systematic and interdisciplinary approach to incorporate environmental considerations into their decision-making process.

In following the procedures described in the handbook, the user is involved in both a systematic *and* interdisciplinary process. This is accomplished by following an eight-step algorithm in which details of the proposed action and associated alternatives are identified and evaluated for environmental effects in both the biophysical and socio-economic realm. Briefly, the steps in the procedure are outlined as follows:

Step 1. Identify the need for an EIA or an EIS.
Step 2. Establish details of the proposed action.
Step 3. Examine environmental attributes, impact analysis worksheets and summary sheets.
Step 4. Evaluate impacts using attribute descriptor package.
Step 5. Summarize impacts on summary sheet.
Step 6. Examine alternatives.
Step 7. Address the eight points of CEQ Guidelines.
Step 8. Process final document.

Examples of representative Army actions that might have a significant environmental impact (Step 1) are given, and guidance is provided in the identification of Army activities (Steps 2 and 4) in nine functional areas:

1. Construction
2. Operation, Maintenance and Repair
3. Training
4. Mission Change
5. Real Estate
6. Procurement
7. Industrial Activities
8. Research, Development, Test and Evaluation
9. Administration and Support.

Environmental attributes (Steps 3 and 4) are identified and characterized in detail via "descriptor packages" located in Appendix A of the handbook. The environmental attributes are forty-six (46) in number and are classified in the following categories:

1. Air
2. Water
3. Land
4. Ecology
5. Sound
6. Human
7. Economic.

Each attribute descriptor package is comprised of the following:

A. Definition

B. Army activities which affect the attribute
C. Source of effects
D. Variables to be measured
E. How variables are measured
F. Evaluation and interpretation of data
G. Special conditions
H. Geographic and temporal effects
I. Mitigation of impact
J. Other comments
K. References or other information sources.

After evaluating the effect of the proposed action and the alternatives (Step 6) on the interdisciplinary attributes, and summarizing the effects (Step 5), it is recommended that the assessment be documented in the format suggested by the CEQ Guidelines (Step 7). Each of the eight points in the CEQ Guidelines are discussed in detail and Army-related examples are presented.

Finally, information regarding processing of assessments and statements (Step 8) is given.

FOREWORD

This Handbook supports the Army Environmental Program and allows Army personnel to be responsive to the provisions of the National Environmental Policy Act.

Development of the Handbook was made possible through efforts of Army staff personnel knowledgeable in Army activities and scientists and engineers at CERL and the Battelle-Columbus Laboratories.

This Handbook specifically addresses Army military programs. Some aspects of the Handbook—for example Chapters 1, 2, and Appendix A—might be useful to individuals dealing with environmental impact analysis related to other federal agency programs.

Although much time was devoted to make this a clear and understandable document, it is possible that it will not fully satisfy the user's needs. It is therefore requested that recipients evaluate the Handbook through its use during the course of their normal duties. Comments/recommendations to improve this document should be forwarded to: CERL (Attn: Dr. Jain/Handbook), P.O. Box 4005, Champaign, IL 61820. These comments will be used for future updating and revising of this document.

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ABBREVIATIONS

AIT	Advanced Individual Training
AMC	Army Materiel Command
ARMCOM	Armament Command
ASPR	Armed Services Procurement Regulations
AUT	Advanced Unit Training
BCT	Basic Combat Training
BUT	Basic Unit Training
CEQ	Council on Environmental Quality
DA	Department of the Army
DEIS	Draft Environmental Impact Statement
DoD	Department of Defense
EIA, EA, or EAS	Environmental Impact Assessment, Environmental Assessment, or Environmental Assessment Statement
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FORSCOM	Forces Command
HQ	Headquarters
HQDA	Headquarters, Department of the Army
HUD	Housing and Urban Development
HVAC	Heating, Ventilating, and Air Conditioning
MASAQHE	Major Action Significantly Affecting the Quality of the Human Environment
NATO	North Atlantic Treaty Organization
NEPA	National Environmental Policy Act
OASD (H&E)	Office of the Assistant Secretary of Defense (Health and Environment)
OBERS	Bureau of Economic Analysis (Department of Commerce/Economic Research Service) (Department of Agriculture)
OCE	Office of the Chief of Engineers
ODCSLOG	Office, Deputy Chief of Staff for Logistics
ODUSA	Office of the Deputy Under Secretary of the Army
OMB	Office of Management and Budget
ORT	Operational Readiness Training
OSD	Office of Secretary of Defense
POL	Petroleum, Oils and Lubricants
RDTE	Research, Development, Test and Evaluation
TAGO	Office, the Adjutant General of the Army
TRADOC	Training and Doctrine Command

CHAPTER 1

INTRODUCTION

This handbook has been prepared to assist Army users in the preparation and review of Environmental Impact Statements (EIS) and Environmental Impact Assessments (EIA) which stem from the requirements of the National Environmental Policy Act (NEPA). Guidelines for being responsive to the Act have been published by the Council on Environmental Quality (CEQ). Those charged with the duty of responding to NEPA and CEQ guidelines are immediately faced with a series of questions. Some of these include:

- What is NEPA?
- Why is NEPA important to the Army?
- What are the CEQ guidelines?
- What specifically do I as a commander have to do?
- What is an environmental impact assessment (EIA)?
- What is an environmental impact statement (EIS)?
- How do the EIA and EIS differ?
- What information do I need to present?
- What format is used to report the environmental analysis?
- What do I do with an EIA or EIS after preparing it?

These questions are answered in this handbook; in addition, scientific information is provided to allow the user to relate Army activities to potential environmental impacts.

Chapter 1 serves as an introduction to the entire publication and provides the reader with adequate background and definition to make the rest of the handbook meaningful. In addition, this chapter provides background information on the various elements of NEPA, the EIA and EIS, and the impact-assessment process and the development of the need for this process.

Chapter 2 outlines the step-by-step procedure for the preparation and processing of an EIA or EIS. In most cases, the user will utilize this chapter most frequently and only refer to other parts of the handbook for additional technical guidance. Since Chapter 2 is the core of the handbook, it is set apart by color to facilitate usage.

Chapter 3 describes the environmental-attribute descriptor package, Army activities associated with implementing the various Army programs, and impact-assessment matrices and worksheets.

Appendix A includes a detailed write-up on the various elements of the environment—these are referred to as attributes. Scientific information regarding the environmental attributes will assist the user in relating Army activities to potential impacts from these attributes.

NATIONAL ENVIRONMENTAL POLICY ACT

On January 1, 1970, the President signed the National Environmental Policy Act (NEPA) into law. The enactment of this law established a national policy of encouraging productive and enjoyable harmony between man and his environment. The symbolism of the timing of this law did not go unnoted by the President, who heralded the 70's as a decade of environmental concern. Title I of NEPA set forth the national policy on restoration and protection of environmental quality, and Title II established the Council on Environmental Quality (CEQ) as an environmental advisory body for the Executive Office.

CEQ is charged with the responsibility to study the condition of the nation's environment, to develop new environmental programs and policies, to coordinate the wide array of Federal environmental efforts, to see that all Federal activities take environmental considerations into account, and to assist the President in assessing environmental problems and in determining ways to solve them.

NEPA, in setting forth the national policy on restoration and protection of environmental quality, has declared that it is the continuing policy of the Federal Government, in cooperation with state and local governments and other concerned public and private organizations, to create and maintain conditions under which man and nature can exist in productive harmony and fulfill social, economic, and other requirements of present and future generations of Americans.

Some of the beneficial effects of NEPA are:

1. To bring national policies in line with modern concerns for environmental quality
2. To provide a systematic way of dealing with problems that transcend the parochial interest of individual Federal agencies and individual interest groups
3. To open governmental activities to public scrutiny and public participation
4. To staff governmental agencies with personnel capable of undertaking the interdisciplinary approach required by NEPA
5. To allow for citizen suits to provide for the enforcement of the requirements of NEPA.

All Federal agencies, in being responsive to NEPA, must be concerned with the impact of man's activities on the environment.

DEFINITION OF IMPACTS

Consisting of both natural and man-made factors, the environment is difficult to characterize because of its many attributes (variables) and the complex interrelationships among these attributes. Changes in the attributes of the environment and their interrelationships are defined as impacts.

An EIA or EIS is prepared to characterize the environment and potential changes to be brought about by a specific activity. Such a document is advantageous in that it presents an organized and complete information base for achieving the benefits intended by NEPA.

Attributes

Variables that represent characteristics of the environment are defined as attributes, and changes in environmental attributes provide indicators of changes in the

environment. All lists of environmental attributes are a shorthand method for focusing on important characteristics of the environment. Due to the complex nature of the environment, it should be recognized that any such listing is limited and consequently may not capture some of the real world impacts. However, the more complete the listing is, the more likely it will reflect all important effects on the environment. Presented in Appendix A is a listing of environmental attributes and a descriptor package to assist in defining impacts.

With and Without the Project

The conditions for estimating environmental impact are to measure attributes with and without the subject project or activity at a given point in time. Figure 1.1 indicates the measure of an attribute with and without an activity over time. From this example it can be seen that the measure of the attribute may change over time, without the activity. Therefore, the impact must be measured in terms of the "net" change in the attribute at a given point in time.

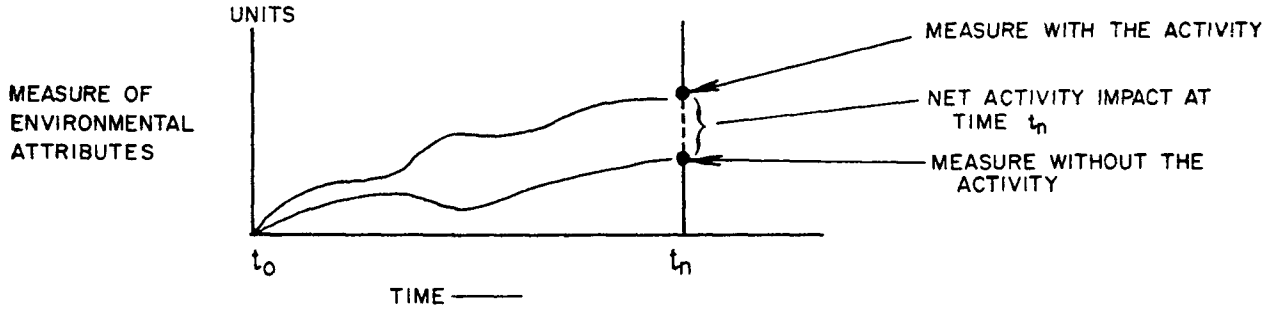

FIGURE 1.1. MEASURE OF IMPACT WITH AND WITHOUT ACTIVITY

This concept of impact is used to avoid problems of comparing the present measure (without the activity) with the future measure with the activity. The difficulty is that data for a with and without activity projection of impacts are difficult to obtain, and results are difficult to verify.

Environmental Impact Assessments and Statements

The assessment and statement differ in purpose and use. The purpose of the environmental impact assessment (EIA)* is to provide a basis for intra-agency review of project impacts. The EIA is designed to provide adequate information for judging whether an environmental impact statement (EIS) should be prepared.

An EIS is a similar detailed analysis of the environmental consequences of a proposed action. Federal agencies are required to prepare and use an EIS in their agency review and decision-making processes and to submit the statement to CEQ. This is to be accomplished before the agency undertakes any major action that significantly

*Some agencies and commands refer to EIA as environmental assessment (EA) or environmental assessment statement (EAS).

affects the quality of the human environment or which is controversial for environmental reasons. The Federal agency that is responsible for preparing an EIS is the proponent agency.

The broad spectrum of federal actions range from minor to major. However, most are not major (significant commitment of resources) and many do not have a significant environmental impact. Where it is apparent that the proposed action is minor, and there will be no adverse environmental impact, a simple declaration of that fact is sufficient for record purposes. Such a declaration should be made early in the planning process and be made part of the planning documentation on the proposed action. In other words, the planner should include a statement in his written records that an environmental assessment was made and it was concluded that the action is not major nor will it have a significant impact on the environment.

Between those actions having an obvious and significant environmental impact requiring and EIS and those having nearly none, there are a large variety of actions where it is difficult to determine off hand the extent of their environmental impact. To keep a planner from resorting to snap judgments in such instances an environmental impact assessment will be prepared. This is an analysis much like an EIS, but it is not prepared in the same depth nor need it include all of the elements of an EIS. For example, there is no requirement to examine various alternative courses of action when the analysis of a preferred course of action reveals there is no significant impact on the environment. However, any assessment of an action should identify all direct and indirect environmental impacts, giving particular attention to the unavoidable long-term adverse impacts and any irreversible commitments of resources (ecological and material) that may result from proceeding with the action.

A properly prepared assessment should enable the planner to conclude whether the proposal should or should not be regarded as a major action; whether the environmental impact is or is not significant; and if the action could be environmentally controversial. Whenever it is concluded that significant environmental impact will result from a proposed action or it may become environmentally controversial when others learn of the action, a draft EIS must be prepared.

As a word of caution, it is not prudent for a planner to avoid preparing an EIS by understating the possible impact of the action. An important project could be lost or seriously delayed by approving authorities at higher headquarters who may question the validity of a determination that there is no environmental impact. Similarly, doubts could be raised by others outside the Army, to include private citizens, who may exercise their right to take legal action to enjoin the action until the environmental impact of the action is fully disclosed.

As an aid to Army planners, a listing of those actions which normally require an EIS has been compiled and is included in this handbook. For the most part, the actions listed can normally be expected to produce adverse environmental consequences. However, there are situations where it is possible for the impact to be less than significant. Such a determination can only be made by completing an environmental impact assessment which fully discusses all the elements required for an EIS. Should it be concluded that a draft EIS need not be prepared, a statement must be provided HQDA (OCE, Environmental Office) that an EIS will not be prepared, the reasons for that conclusion, and the date such a determination was made.

All data developed in the use of this manual are useful in preparing both the EIA and the EIS.

LEGISLATIVE BASIS

Section 102(2)(C) of NEPA forms the legislative basis for the requirement for preparing environmental impact statements. In essence, to insure that environmental amenities and values are given systematic consideration equal to economic and technical considerations in the Federal decision-making process, NEPA requires each Federal agency to prepare a statement of environmental impact in advance of each major action including but not limited to recommendations for legislation; new and continuing project and program activities; and the making, modification, or establishment of regulations, rules, procedures, and policies that may significantly affect the quality of the human environment.

The primary purpose for preparing environmental-impact statements is to disclose the environmental consequences of a proposed action, thus, alerting the agency decision maker, the public, and ultimately Congress and the President to the environmental risks involved. An important and intended consequence of this is to build into a Federal agency's decision-making process a continuing consciousness of environmental considerations.

Executive Orders and Agency Response

To further enhance and explain NEPA, several Executive Orders were issued by the President, and the Federal agencies responded with appropriate guidelines and directives. Important elements of the Executive Orders and agency responses are presented herein.

Executive Order 11752, "Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities," 17 December 1973

> Section 1. Policy. It is the purpose of this order to assure that the Federal Government in the design, construction, management, operation, and maintenance of its facilities shall provide leadership in the nationwide effort to protect and enhance the quality of our air, water, and land resources. . . .

Executive Order 11514, "Protection and Enhancement of Environmental Quality," 5 March 1970

> Section 1. Policy. The Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals. The Council on Environmental Quality, through the Chairman, shall advise and assist the President in leading this national effort. . . .

Also, the heads of Federal agencies are required to

> monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment. . . .

DoD Directive 6050.1, "Environmental Considerations in DoD Actions," 19 March 1974

This directive establishes the continuing policy of the Department of Defense, as a

trustee of the environment, to demonstrate leadership and carry out its mission of national security in a manner consistent with national environmental policies and host country environmental standards, laws and policies.

Toward this end, DoD components shall:

1. Assess at the earliest practical stage in the planning process and in all instances prior to the first significant point of decision, the environmental consequences of proposed actions.

2. Review those continuing actions initiated prior to enactment of P.L. 91-190 for which the environmental consequences have not been assessed and ensure that any of the remaining actions are consistent with the provisions of the directive.

3. Utilize a systematic interdisciplinary approach in planning and decision making.

4. Prepare and process under the criteria contained in the directive a detailed environmental impact statement on every recommendation or report on proposals for legislation and other major defense actions which are expected to be environmentally controversial or could cause a significant effect on the quality of the human environment.

5. Study, develop and describe appropriate alternatives to the recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.

DA AR 200-1, "Environmental Protection and Enhancement,"7 Dec 73

This regulation provides general Department of the Army policy on environmental protection. Chapter 2 titled "Environmental Considerations in DA Actions" provides basic guidance for Army actions.

Guidelines

Eight Major Points

Guidelines for the preparation of environmental impact statements were issued by CEQ in August 1973.* These guidelines clarify the content of environmental impact statements. These concern types of impacts to be covered, points to be discussed, the extent of secondary impacts to be included, appropriate alternatives to evaluate, and requirements for negative declaration decisions. The eight major points to be covered by impact statements are summarized as:

1. A description of the proposed action, a statement of its purpose, and a description of the environmental setting of the project
2. The relationship of the proposed action to land-use plans, policies, and controls for the affected area
3. The probable impact of the proposed action on the environment
4. Alternatives to the proposed action, *including* those not within the existing authority of the responsible agency
5. Any probable adverse environmental effects that cannot be avoided (summarizing the unavoidable parts Point (3) and, separately how avoidable parts Point (3) will be mitigated)
6. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity
7. Any irreversible and irretrievable commitments of resources (including natural and cultural as well as labor and materials)
8. An indication of what other interests and considerations of Federal policy are thought to offset the adverse environmental effects identified.

Secondary Impacts

Secondary or indirect consequences for the environment should be addressed, especially as related to infrastructure investments that "stimulate or induce secondary effects in the form of associated investments and changed patterns of social and economic activity." These effects may be produced "through their impact on existing community facilities and activities, through induced new facilities and activities, or through changes in natural conditions." A specific example calls out possible changes in population patterns and growth that may have effects upon the resource base including land use, water, and public services. In the biophysical environment, the secondary impacts can also be important. For example, removal of vegetation may cause excessive soil erosion which may cause excessive sediments in the receiving stream. This in turn will reduce the amount of sunlight that can penetrate the water, thus reducing the dissolved oxygen in the water. Dissolved oxygen plays an important role in the biological economy of water. Reduction in dissolved oxygen will adversely affect aquatic life and water quality of the stream.

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*Preparation of Environmental Impact Statements: Guidelines, *Federal Register*, Volume 38, Number 147, Part II, August 1, 1973, pp 20550-20562.

Alternatives

Examples of alternatives to the proposed action to be considered are:

- No action alternative
- Actions of a significantly different nature which would provide similar benefits with different environmental impacts (including those outside the authority of the responsible agency)
- Alternatives related to different designs and/or project and activity site
- Alternative measures to provide for compensation of fish and wildlife losses.

Negative Declaration Decisions

All major commands are required to report those actions requiring environmental statements and those actions not likely to require statements (negative declaration). Normally this process will involve:

- Making an initial assessment of the impacts typically associated with principal types of agency action
- Identifying (on the basis of this assessment) types of actions that normally do and do not require statements
- With respect to remaining actions that may or may not require statements, depending on the circumstances, identifying (a) what basic information needs to be assembled and analyzed, how and when, (b) on what basis the decision to prepare EIS or negative declaration will be made.

FUNCTION AND PURPOSE OF THE IMPACT-ASSESSMENT PROCESS

Environmental-impact assessment should be undertaken for reasons other than to simply conform to the law. According to the letter of the law, environmental impact must be assessed for activities with significant impact. However, the spirit of the law is founded on the premise that to utilize resources in an environmentally compatible way, it is necessary to know how activities will affect the environment and to consider these effects early enough so that changes in plans can be made if the potential impact warrants it.

In standard cost-benefit analysis and program evaluation, the intangible impacts on the environment are not taken into account. The impact-assessment process provides the basis for operating within the spirit of the law by encouraging recognition of impacts early in the planning process and by providing a source of information (inventory) of the environmental effects of man's activities.

Planning

The planning process inevitably involves projecting activities into the future to determine how well projected activities conform to anticipated alternative futures. Planning also permits a continuity of activities that serves to fulfill long-term objectives and goals. The methods for dealing with short-term exigencies and complexities can be identified only with reference to the long-term plan.

Environmental-impact assessment fits into the long-term planning process because it provides the vehicle for identifying the potential effects of activities on the environment. While immediate knowledge of these effects is important, the long-term aspects of impact are probably more important because only on a longer time horizon can adequate, effective, and low-cost alternatives to reduce the impact be identified.

If, for example, the potential for an adverse impact of an activity or program planned for 5 years in the future was identified, adequate time to consider significant mitigation alternatives (including stopping the program) would exist. This is to be much preferred to finding out about serious impacts after an activity is half completed. At the later point in time, modifications to reduce the impact could be very costly or opposition could force costly delays in completion or even prevent continuation. This could cause a loss of invested time and money.

Inventory

Historically, few records have been maintained of the environmental effects of activities. Environmental impact assessments and statements provide a vehicle for recording impacts of activities so that knowledge of what adverse changes may occur can be collected and maintained. The purpose of the inventory is to insure disclosure of the impacts so that concerned institutions or individuals will be aware of possible repercussions of the subject activity.

Another valuable use for the inventory of impacts is to identify the potential cumulative effects of a group or series of activities in an area. Any single activity may not likely result in serious changes in the environment, but when its effects are added to those of other projects, the impacts on the environment may be severe. The

potential for cumulative impacts must be identified, and in some cases, this may be possible only at the intra-agency level. Thus, to account for cumulative impacts it might be more desirable to assess the environmental impact at a program level which covers many projects or activities.

ELEMENTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The distinction between environmental impact and changes in environmental attributes is that changes in the attributes provide for an indication of changes in the environment. In a sense, the set of attributes must provide a model for the prediction of all impacts. The steps in the impact assessment process are:

- Identification of impacts on attributes
- Measurement of impacts on attributes
- Aggregation of impacts on attributes to reflect impact on the environment
- Reporting findings for use by others.

Identification of Impacts

The list of environmental attributes that might be evaluated is practically infinite because *any* characteristic of the environment is an attribute. Therefore, it is necessary to reduce the number of attributes to be examined. Thus, duplicative, redundant, difficult to measure, and obscure attributes may be eliminated in favor of those that are more tractable. This procedure is valid only if the remaining attributes reflect all aspects of the environment. This means that some attributes, difficult to measure or conceptualize, may remain to be dealt with.

Thus, identification of impacts is based on a review of potentially impacted attributes to determine whether they will be affected by the subject activity.

Characteristics of the Base

Conditions Prior to the Activity. The nature of the impact is determined by the conditions of the environment prior to the activity. Base data are information regarding what the measure of the attributes would be (or is) prior to the activity in place. Because the measurement and analysis of environmental impact cannot take place without base data, identifying the characteristics of the base is critical.

Geographic Characteristics. There may be significant differences in impact on attributes for a given activity in different areas. Geographical location is, therefore, one of the factors that affects the merit or relative importance of considering a particular attribute. For example, the impact of similar projects on water quality in an area with abundant water supplies versus impact in an area with scarce water resources would differ significantly. The spatial dispersion of different activities introduces one of the difficult elements in comparing one activity and its impact with another.

Temporal Characteristics. Time may also pose problems for the impact analysis. It is essential to insure that all impacts are examined over the same projection time period. Furthermore, to adequately compare (or combine) activity impacts it is necessary that the same time period (or periods) apply.

Measurement of Impact

Identifying the impact of a project on an attribute leads directly to the second step of measuring the impact. Ideally, all impacts should be translatable into common units. This is, however, not possible because of the difficulty in defining impacts (e.g., on income and on rare and endangered species) in common units. In addition to the difficulties in quantitatively identifying impacts are the problems that arise because quantification of impacts may be beyond the state of the art. Thus, the problems of measuring and comparing them with quantitative impacts are introduced.

Quantitative Measurements

Quantitative measurements of impact are measures of projected change in the relevant attributes. These measure units must be based on a technique for projecting the changes into the future. The changes must be projected on the basis of a no-activity alternative. One difficulty in assessing the quantitative change arises from the fact that changes in attributes may not be in common units. In addition, there are difficulties in assessing the change in the attributes through the use of projection techniques.

Qualitative Measurements

Changes in some attributes of the environment are not amenable to measurement. The attribute may not be defined well enough, in its relationship to overall environment, to determine what the most adequate measurable parameter might be. Therefore, instead of a specific measure, a general title and definition may be all that is available. In such cases, it may be necessary to rely on expert judgment to answer the question of how attributes will be affected by the subject project.

Aggregation

After measuring project impacts on various attributes, two aggregation problems must be addressed. The first problem deals with how to aggregate among the different attributes (quantitative *and* qualitative) to arrive at a single measure for activity impact. This involves expressing the various impact measures in common units. Then, a method for comparing the impacts on specific attributes must be identified. (Some methodologies utilize a weighting procedure to accomplish this.) Finally, the impacts may be summed and compared with the impact of an alternative activity. The procedure in this handbook stops short of an explicit weighting and summing procedure.

A single Army activity may produce a negligible effect on the environment. However, a series of similar activities may produce cumulative effects on certain aspects of the environment. This raises the question of how to deal with these potential cumulative effects. The most obvious solution is to prepare impact assessments on broad programs rather than on a series of component actions. Unfortunately, the definition of activities at the program level may be so vague as to preclude identification of impacts on the attributes of the environment. Nevertheless, review of Army activities at the program level, requiring enough detail to evaluate impacts, is the best way to handle the problem of cumulative impacts.

REPORTING FINDINGS

The results of the impact assessment are reported as an environmental impact assessment or as a statement. However, it is useful to consider displaying the results in a way that makes it easy to comprehend total impact from a brief review. Methods for doing this are suggested in the subsequent chapters.

CHAPTER 2

THE IMPACT ASSESSMENT PROCEDURE AND CEQ GUIDELINES

This chapter introduces a step-by-step procedure to prepare environmental impact assessments or statements that meet Army requirements as well as those of CEQ. Army activities are categorized into functional areas, and these are considered in relationship with the eight points in the CEQ guidelines. The CEQ-prescribed EIS format is outlined and its contents are detailed.

IMPACT ASSESSMENT PROCEDURE

The National Environmental Policy Act (NEPA) has the primary goal of incorporating environmental considerations into the decision-making process. NEPA cannot be used, nor was it intended to be utilized to stop projects, provided the requirements of the Act are fulfilled. The essence of these requirements is simple: use a systematic and interdisciplinary approach to evaluate the environmental consequences of the proposed action, and incorporate the results into the decision-making process. If this is done in a complete, honest, and straightforward manner, NEPA is satisfied. The project or action may be an environmental disaster—but if the probable consequences are known, fully disclosed, and weighed in with other aspects of the action, then the letter and the spirit of NEPA have been fulfilled. It is only when the environmental assessment procedure is looked upon as a "paper exercise," or when the assessment is done in an incomplete or shortsighted manner, that permanent legal difficulties can arise.

ARMY OPERATIONS

An important and intended consequence of preparing an EIA or an EIS is to build into a Federal agency's decision-making process a continuing consciousness of environmental considerations. In order to do this, it must be emphasized again that *considerations of environmental factors must be integrated into existing Army procedures, and environmental factors must be considered from the very beginning of the planning process.* Therefore, an agency should prepare an EIA as early in the decision-making process as possible, and in all cases, *prior* to an agency decision. *It is a misconception to think that an EIA is required only for construction projects.* Army activities other than construction, for example, training exercises, mission change of facilities, and industrial activities, also require preparation of assessments or statements. To cover the many activities that involve Army elements, Army operations have been categorized into nine functional areas:

- Construction
- Operation and maintenance
- Training
- Mission change

- Real estate
- Procurement
- Industrial activities
- Research, development, test and evaluation
- Administration and support

For each of these functional areas, Chapter 3 includes detailed activities associated with implementing Army programs and a brief introduction to the functional area. Note that these functional areas are not meant to be mutually exclusive. For example, a construction project may involve acquisition of real estate and the subsequent operation, maintenance, and repair of the facility.

STEP-BY-STEP PREPARATION

Step 1. Identify the Need for Preparing an EIA or an EIS

Basically, all Federal agencies are required to prepare an environmental impact assessment for implementing their major programs. *It is suggested that an assessment be prepared on a program level which covers many projects or activities.* This will reduce the number of assessments to be prepared, and the assessment will be more comprehensive and meaningful. The many Army activities that require an EIA may be identified by reviewing the nine functional areas mentioned above. After preparing an assessment, one is required to answer the following questions:

- Will the implementation of the program have a significant adverse effect on the quality of the human environment?
- Will the action be environmentally controversial?

If the answer to either of these two questions is yes, then the proponent agency is required to prepare an EIS. Figure 2.1 further describes the relationship between the EIA and the EIS.

Figure 2.2 shows a list of representative major actions that might have a significant environmental impact or whose impact on implementation might be considered controversial.

As an example, assume that scheduled programs at an installation include construction of 200 units of family housing (Example A) and a large scale armored training exercise (Example B). Examination of Figure 2.2 indicates that these actions correspond to item no. 20 and no. 22 in the list of representative Army actions that might have a significant environmental impact. These actions therefore must be assessed to determine whether or not they will be environmentally significant or controversial.

Step 2. Identify Relevant Army Activities

Identify detailed activities associated with implementing the project or the program. Categorized in Chapter 3 are Army activities in nine functional areas; for each functional area detailed activities associated with implementing projects or programs are listed. The user should supplement these activities with project-specific activities.

For Example A, the construction activities shown in Figure 3.5 should be reviewed. Those activities not applicable to the project should be crossed off and supplemental activities should be added to encompass the project-specific

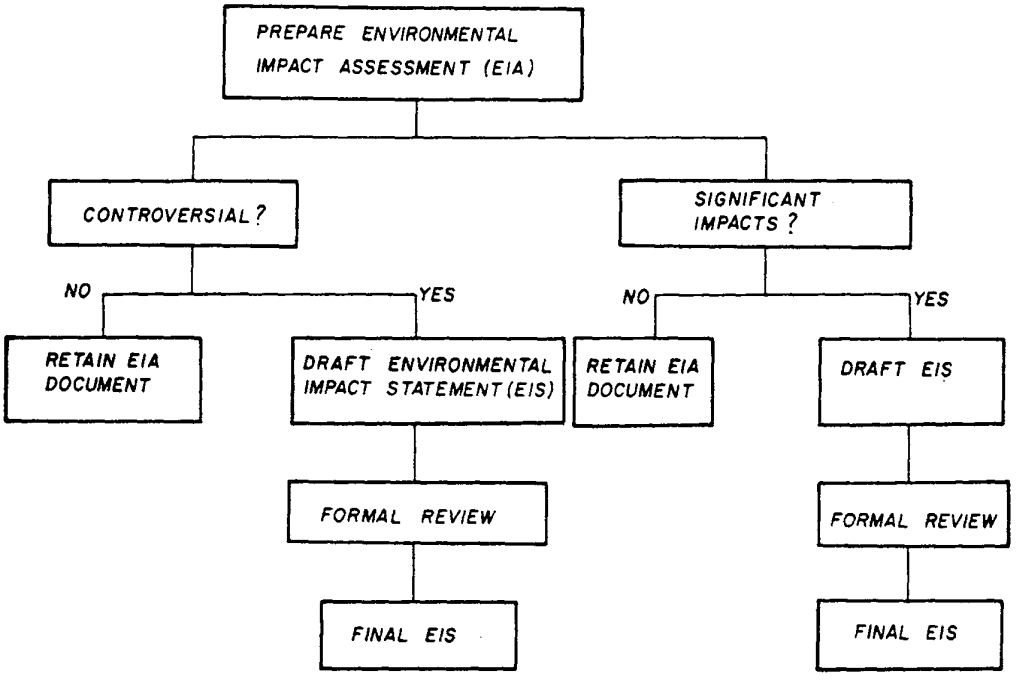

FIGURE 2.1. INTERRELATIONSHIP OF EIA AND EIS

requirements.

Step 3. Examine Attributes to be Reviewed

Examine and familiarize yourself with (1) environmental attributes in Appendix A, (2) impact analysis worksheets (Figures 3.5 through 3.10), and (3) summary of impact sheet (Figure 3.4).

Step 4. Evaluate Impacts Using Descriptor Package and Worksheets

Use the attribute descriptor package Appendix A to:

- Identify potential impacts on the environment by placing an "X" at the appropriate element of the worksheet.
- Collect baseline data on the impacted attributes.
- Quantify the impact where possible.

For instance, construction of a 200 unit family housing project (Example A), might require large scale excavation which might cause erosion, increased suspended solids in the receiving waters of the stream and decreased dissolved oxygen. Mark "X" for all such negative potential impacts in the worksheet and "⊕" for positive potential impacts.

Step 5. Summarize Impacts

For the potential impacts, marked with "X" or "⊕" on the worksheet, summarize the impacts using Figure 3.4.

1. Development or purchase of new type of aircraft or other mobile facilities or substantially modified propulsion system.
2. Development or purchase of new weapon system.
3. Real estate acquisition or outleases or permitting or exchange or disposal of real estate.
4. Major construction projects.
5. New installations.
6. Production, storage, relocation, or disposal of chemical munitions, pesticides, herbicides, and containers.
7. Use of pesticides or herbicides, when proposed for use other than in accordance with the label as registered.
8. Harvesting of timber, wildlife, etc. (significant amounts).
9. Intentional disposal of any substances in a significant quantity or on a continuing or periodic basis.
10. Mission changes and troop deployments which increase or decrease population in any area.
11. Major research and development projects and test programs associated with R&D projects.
12. Any action which, because of real, potential, or purported adverse environmental consequences, is a highly controversial subject among people who will be affected by the action, or which, although not the subject of controversy, is likely to become a highly controversial subject when it becomes known to the public.
13. New, revised, or established regulations, directives, or policy guidance concerning activities that could have an environmental effect (e.g., training, construction, or mission change). Regulations, directives, or policy guidance limit any of the alternative means of performing the actions on this list. Broad programs which could indirectly affect other actions on this list (e.g., Volunteer Army Program, Energy Conservation Program, or Expansion of the Women's Army Corps).
14. Intentional disposal of any materials in the oceans or other bodies of water.
15. Large quarrying, timbering, or earth-moving operations.
16. Airfield and range operations for test or training purposes.
17. Constructing, installing, or maintaining fences or other barriers that might prevent migration or free movement of wildlife.
18. Approval of new sanitary landfills, incinerators, and sewage treatment plants and operation of existing facilities.
19. Existing or changes to master plans.
20. Construction or acquisition of new family housing over 25 units.
21. Dredging.
22. Exercises involving divisional or larger units on or off Federal property, or where significant environmental damage may occur regardless of unit sizes.
23. Exercises involving smaller units when the training involves non-Army property or there is a significant amount of heavy or noisy equipment involved.
24. New deployment or relocation or disposal of nuclear power plants.
25. Operation of existing or new government-owned production facilities.
26. Ammunition storage facilities, new or continuing operations, or transportation of ammunition.
27. Closing or limiting of areas that previously were open to public use; that is, roads or recreational areas, etc.
28. Activities that will or may increase air or water pollution or disrupt plant life on the real estate.
29. Construction on flood plains or construction that may cause increased flooding.
30. Fuel conversion or continued consumption of significant quantities of fuel in short supply.
31. Increase in energy requirements.
32. Channelization of streams.
33. New facilities for aircraft, increase in number of aircraft at existing fields, and operation of existing aircraft in significant numbers.
34. Activities in wetland areas.
35. Storage, use, and disposition of POL products.
36. Use, storage, and disposition of radioactive materials, other than as authorized in Title 10, code of Federal regulations.
37. Operation and maintenance of power-generating equipment.
38. Control of pest organisms such as birds or other animals.
39. Construction of roads, transmission lines, or pipelines.
40. Award or termination of major contracts for supplies of natural resources; e.g., coal, oil, etc.
41. Transportation and testing of chemical agents and munitions.
42. Determination of safety standards, especially quantity-safety distances.
43. Development or purchase of new types of equipment, other than mobile facilities and weapon systems.
44. Outdoor large-scale or controversial testing of newly developed systems or material.
45. Continued operation of existing facilities which are causing pollution.

FIGURE 2.2. REPRESENTATIVE ARMY ACTIONS THAT MIGHT HAVE A SIGNIFICANT ENVIRONMENTAL IMPACT

For example, for impacts on erosion, suspended solids, and dissolved oxygen, evaluate the magnitude of the project, site characteristics and utilize the scientific information provided in Appendix A, and then determine the degree or severity of the impact on an attribute. Finally, summarize these impacts by using the key shown in Figure 3.4.

Step 6. Review Other Alternatives

Repeat the procedure for the alternatives considered.

Step 7. Prepare Analysis

Utilize the information from the impact analysis worksheets, summary sheet, and the attribute descriptor package to respond to the eight points of the CEQ guidelines. To assist the user in responding to the eight points, guidance is provided in the following section.

For preparing an EIS, it is mandatory that the eight points as set forth by CEQ guidelines be addressed and documented; however, for preparing an EIA it is not. It is recommended, however, that for preparing an EIA the eight points of CEQ be addressed using a format similar to the EIS. The reason for this is simply that if a statement is required, the procedure would be much further advanced if the assessment had been made following the EIS format. Some commands such as TRADOC and FORSCOM in fact require identical formats for the EIA and the EIS.

Step 8. Process Final Document

After the assessment or statement has been prepared, follow the directives for processing or retention as prescribed by DA and your specific command.

EIS GUIDELINES

General

The latest federal regulations (CEQ guidelines effective January 28, 1974) emphasize that environmental considerations should be taken into account from the beginning of the decision-making process. Initial environmental studies, for example, should be undertaken concurrently with initial technical and economic studies. Too often, in the past, assessments and statements have been written to justify decisions long since made. If environmental assessments had been initiated at the conception of the projects, environmental information could have been integrated into rather than tacked onto the decision-making process, and in many cases delays could have been avoided. The guidelines require that draft impact statements (hence, the required prior assessments) are to be prepared and circulated at the earliest possible stage in the decision-making process.*

*"Environmental Quality," *The Fourth Annual Report of the Council on Environmental Quality*, U.S. Government Printing Office, September 1973.

Format

This section contains specific information regarding the preparation and content of the EIA and the EIS. The following items are covered:

- Sample cover sheet
- Summary sheet
- Outline for CEQ-prescribed EIS format
- Detailed content of EIA/EIS (following the outline).

A sample Cover Sheet is shown in Figure 2.3. The format and content prescribed for the Summary Sheet are shown in Figure 2.4.

Figure 2.5 is the outline for CEQ-prescribed EIS content.

DEPARTMENT OF THE ARMY

Army Command or Agency

Environmental Assessment *or*
Draft Environmental Statement *or*
Final Environmental Statement

Title

Installation or Agency

Date Prepared

Prepared by:

Name and Office

Approved by:

CDR (Command) Installation
or his designee and office

Approved by:

Commander, (Command) or his designee
and office

FIGURE 2.3. SAMPLE COVER SHEET

TITLE

( ) Draft ( ) Final Environmental Statement

Name, address, phone number of official who can be contacted for additional information

Responsible Office:

1. Name of Action: ( ) Administrative ( ) Legislative

2. Description of the Action: Brief summary of the proposed action and its purpose, highlighting important points. Areas affected - specific identity of states (and counties) particularly affected - maps. Other Federal actions in the area which are discussed in this EIS.
3. Summary of Impacts

   a. Environmental Impacts: Brief summary of the impacts expected from the proposed action.

   b. Adverse Environmental Effects: Summary of the adverse environmental effects that will result if the proposed action is implemented.

4. Alternatives: Brief discussion of the alternatives considered.

5. List all Federal, state, and local agencies from which

   a. Comments requested: for draft statements

   b. Comments received: for final statements, otherwise blank.

6. Draft Statement to CEQ: Date the draft statement was forwarded to CEQ by ODUSA.

7. Final Statement to CEQ: Date the final statement was forwarded to CEQ by ODUSA.

FIGURE 2.4. SUMMARY SHEET (Prescribed by CEQ)

DETAILED CONTENT OF EIA/EIS

The ensuing paragraphs indicate details to be included in an EIS that is responsive to the CEQ-prescribed content. The discussion follows the outline presented in Figure 2.5.

1. *Project Description*

Here, the action, activity, or project is described in sufficient detail to provide a reviewer unfamiliar with the proposed action with necessary information to obtain an overview of the action and the circumstances surrounding it. Specifically, the project description should cover the following areas:

a. *Purpose of the action*—Describe the purpose of the action and clearly state its goals and objectives. Explain what the action will accomplish.

b. *Description of the action*—Describe the proposal by name and summarize the activities that will ensue if it is adopted. Some indication of the magnitude of the proposed action should be given, e.g., area extent, number of personnel involved, equipment, manpower, and material requirements.

c. *Environmental setting*—Describe the environment of the area affected as it exists prior to the proposed action. Both biophysical and socioeconomic aspects of the environmental setting should be included, e.g., location, mission, historical data,

1. PROJECT DESCRIPTION
   a. Purpose of action
   b. Description of action
      (1) Name
      (2) Summary of activities
   c. Environmental setting
      (1) Environment prior to proposed action
      (2) Other related Federal activities
2. LAND-USE RELATIONSHIPS
   a. Conformity or conflict with other land-use plans, policies and controls
      (1) Federal, state, and local
      (2) Clean Air Act and Federal Water Pollution Control Act Amendments of 1972
   b. Conflicts and/or inconsistent land-use plans
      (1) Extent of reconciliation
      (2) Reasons for proceeding with action
3. PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT
   a. Positive and negative effects
      (1) National and international environment
      (2) Environmental factors
      (3) Impact of proposed action
   b. Direct and indirect consequences
      (1) Primary effects
      (2) Secondary effects
4. ALTERNATIVES TO THE PROPOSED ACTION
   a. Reasonable alternative actions
      (1) Those that might enhance environmental quality
      (2) Those that might avoid some or all adverse effects
   b. Analysis of alternatives
      (1) Benefits
      (2) Costs
      (3) Risks
5. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED
   a. Adverse and unavoidable impacts
   b. How avoidable adverse impacts will be mitigated
6. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY
   a. Trade-off between short-term environmental gains at expense of long-term losses
   b. Trade-off between long-term environmental gains at expense of short-term losses
   c. Extent to which proposed action forecloses future options
7. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES
   a. Unavoidable impacts irreversibly curtailing the range of potential uses of the environment
      (1) Labor
      (2) Materials
      (3) Natural
      (4) Cultural
8. OTHER INTERESTS AND CONSIDERATIONS OF FEDERAL POLICY THAT OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION
   a. Countervailing benefits of proposed action
   b. Countervailing benefits of alternatives

FIGURE 2.5. OUTLINE FOR CEQ-PRESCRIBED EIS CONTENT

climate, topography, and population data. Unusual or important elements or features of the existing situation should be pointed out. For example, the existence of landmarks, rare timber stands, or unique community social characteristics should be identified.

In developing the activity-description information, summary technical data, maps, and diagrams should be provided where relevant. Highly technical data may accompany the description as an attachment or be footnoted and referenced but should not appear in the description itself.

Information necessary for the environmental setting may come from either or both of the following sources:

- Existing data sources, e.g., soil, climatological, hydrological information from installation master plan, USGS, SCS, EPA, state agencies, and historical societies
- Acquired data sources, using available personnel capabilities or other means.

To ensure accurate descriptions and environmental assessments, site visits should be made where feasible. A first-hand accounting undoubtedly simplifies matters for both the preparer and the reviewer.

When population and growth characteristics are a factor, consideration should be given to using the rates of growth in the project region. These rates are contained in a projection compiled for the Water Resources Council by the Bureau of Economic Analysis of the Department of Commerce and the Economic Research Service of the Department of Agriculture (the "OBERS" projection).

All sources of data used to identify, quantify, or evaluate any and all environmental consequences must be expressly noted and referenced.

2. *Land-Use Relationships*

Here the description relates the proposed action to land-use plans, policies, and controls for the affected area. Specifically, the discussion of land-use relationships should cover the following areas:

a. *Conformity or conflict with other land-use plans, policies, and controls*—Describe how the proposed action may conform or conflict with the objectives and specific terms of plans, policies, and controls imposed by either of the following categories:

(1) *Federal, state, and local*—Consider approved or proposed Federal, state, and local land-use plans, policies, and controls. Compare the land-use aspects of the proposed action and discuss possible compatibilities or conflicts. For example, discuss siting of an extremely noisy activity adjacent to a residential area, or outleasing of land for purposes inconsistent with state wildlife management policies.

(2) *Clean Air Act or Federal Water Pollution Control Act Amendments of 1972*—Policies and controls affecting land-use plans are being developed in response to the Clean Air Act and the Federal Water Pollution Control Act of 1972. The extent of conformity or conflict with these land-use plans must be considered. For example, the EPA has issued regulations requiring states to approve, in advance, the siting and construction of both new "polluting facilities" and such "complex facilities" as shopping centers, amusement parks, and highways which could cause a violation of air-quality standards by attracting concentrations of vehicles.

b. *Conflicts and/or inconsistent land-use plans*—When a conflict or inconsistency exists, the statement should describe the following:

(1) *Extent of reconciliation*—Describe the extent to which the proponent has

reconciled its proposed action with the plan, policy, or control described in a. above. For the preceding examples, such a description may include statements indicating restriction of construction activities to normal daylight working hours, or restriction on agricultural activities during nesting season.

(2) *Reasons for proceeding with action*—Notwithstanding the absence of full reconciliation, the proponent must explain the reasons why it has decided to proceed with the action.

3. *Probable Impact of the Proposed Action on the Environment*

Environmental consequences of the proposed action are summarized in this section. The assessment of the proposed action must include the following:

a. *Positive and negative effects*—Describe both beneficial and detrimental aspects of the environmental changes due to the proposed action. Include commentary on the impact on man's health, welfare, and surroundings. Considerations to be included are the following:

(1) *National and international environment*—Consider the environmental consequences of actions not only as they affect U.S. property and the civilian community, but as they affect areas in or under the jurisdiction of a nation other than the United States.

(2) *Environmental factors*—Among factors to consider should be the potential effect of the action on such aspects of the environment as:

Category	*Location in Manual, Page*
Air	A-1
Water	A-22
Land	A-42
Ecology	A-54
Sound	A-70
Socioeconomic	A-85

Details of the above categories may be found on pages of this handbook as indicated above.

(3) *Impact of proposed action*—The attention given to different environmental factors will vary according to the *nature*, *scale*, and *location* of proposed actions. Primary attention should be given to discussing those factors most evidently impacted by the proposed action.

b. *Direct and indirect consequences*—Identify both direct and indirect effects of the proposed action, activity, or project.

(1) *Primary effects*—Include direct impacts on man's health and welfare and on other forms of life and related ecosystems. Examples of direct effects might include noise from military-aircraft operations or benefits from installation of wet scrubbers to meet air-quality standards.

(2) *Secondary effects*—Include secondary or indirect environmental impacts, particularly on population concentration and growth.* Many Federal actions attract people to previously unpopulated areas and indirectly cause pollution, congestion, and land development that probably would not have existed otherwise. Conversely, other actions may result in displacing population. In the previous examples, noise from aircraft operations may affect future land-use patterns in the area, and the results of air pollution abatement operations may produce a secondary water-

*Refer to section on Secondary Impacts in Chapter 1.

pollution problem from the scrubber waste.

4. *Alternatives to the Proposed Action*

The National Environmental Policy Act specifically requires the proponent to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." Point 4 is in response to this requirement.

Alternatives to the proposed action, including (where relevant) those not within the existing authority of the responsive agency should be discussed. The purpose of this measure is to provide a vehicle by which appropriate consideration of the environmental "pros and cons" for alternatives may be examined early in the planning process in order not to prematurely foreclose options which might enhance environmental quality or have less detrimental effects.

When a preferred course of action is assessed and it is determined that there is no significant environmental impact, there is normally no need to assess alternative courses of action. On the other hand, when there are several courses of action which are equally acceptable, it is appropriate to attempt to identify the alternative which will have the least environmental impact.

a. *Reasonable alternative actions*—In addressing this point, it is necessary to provide a rigorous exploration and objective evaluation of the environmental impacts of all *reasonable* alternative actions—particularly:

(1) Those that might enhance environmental quality

(2) Those that might avoid some or all adverse effects.

b. *Analysis of alternatives*—In evaluating alternatives, the following consequences should be considered and analyzed:

(1) *Benefits*—Discuss benefits which may be derived from an alternative (specifically single out those specified in a. above).

(2) *Costs*—Give an accounting of the environmental costs involved in each alternative, in order that trade-offs between environmental protection and enhancement and associated costs may be evaluated.

(3) *Risks*—Also include specific details regarding potential adverse effects of each alternative, in order that these consequences may be weighed against the costs and benefits.

In discussing alternatives to the proposed action, the following examples of alternatives should be considered:

- No action—treat the alternative of taking no action with the same analysis as outlined above (specifically required).
- Rescheduling action—consider the effects of delaying the action (e.g., postponing training activities until after nesting season, or delaying clearing operations until after wet season).
- Plan modification—examine alternative means of accomplishing the mission or action which would provide similar benefits with different environmental impacts (e.g., simulated versus live firing, or temporary versus permanent haul roads).
- Different design and or site location—consider alternatives related to different designs or details which would present different environmental impacts (e.g., cooling ponds versus cooling tower for a power plant, or alternatives that will significantly conserve energy).
- Compensatory alternatives—examine alternatives that may compensate for fish and wildlife losses. For example, the acquisition of land, waters, and interests therein to compensate for the loss of fish and wildlife habitat caused by the proposed project.

5. *Probable Adverse Environmental Effects Which Cannot be Avoided*

This section should be a brief summary of the effects discussed under Point 3 that are adverse and unavoidable under the proposed action. In response to this point, the following specific items are required:

a. *Adverse and unavoidable impacts*—Summarize those probable adverse effects which cannot be avoided should the proposal be implemented. In addition to an evaluation of damage to the natural environment, this would include a summary of an evaluation of the extent to which human health or safety, aesthetically or culturally valuable surroundings, standards of living, and other aspects of life would be sacrificed or endangered. Such impacts may include the following:

- Water or air pollution resulting from the action
- Destruction of historic or archeological sites
- Disruption of wildlife habitats
- Increase in urban congestion
- Threats to health
- Undesirable land-use patterns
- Other consequences adverse to the environmental goals of the National Environmental Policy Act.

b. *Avoiding Adverse Impacts*—For purposes of contrast, include a clear statement of how adverse effects previously discussed will be mitigated. For example, the following mitigation statements might be applicable:

- Wildlife and vegetation will be protected by limiting vehicular traffic related to training and construction activities to the established routes.
- Training and exercise areas will be thoroughly policed after each use.
- Foxholes and emplacements will be filled upon completion of the training to prevent unnecessary erosion.
- Haul roads will be treated with pallatives to minimize dust production.

From the above examples it is clear, if the section on mitigation of impacts is to have any meaning, that the mitigation procedures indicated in the assessment or statement must be carried out during the implementation of the proposed action. Thus, the inclusion of specific mitigation procedures must be coordinated closely with the proponent and must become a part of the overall design or incorporated into the plan for the proposed action.

6. *Relationships Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity*

This section should contain a brief discussion of the extent to which the proposed action involves short-term versus long-term environmental gains and losses. In this context, short term and long term do not refer to any fixed time periods, but should be viewed in terms of the environmentally significant consequences of the proposed action. Thus, short term may range from a very short period of time during which an action takes place to the expected *life* of a facility. Cumulative effects should be discussed in this section. As before, some of the impacts discussed in Point 3 may be repeated (however, placed in long-term versus short-term format).

a. *Trade-off between short-term environmental gains at expense of long-term losses*—Discuss the relationship between short-term beneficial environmental effects and loss or decrease in long-term productivity or use of land. Incorporate into the discussion any cumulative effects due to continuing or repeated activities. For example, application of herbicides or pesticides may remove undesirable species, but long-

lasting or cumulative effects may permanently damage other vegetative growth or result in disruption of ecological balance.

b. *Trade-off between long-term environmental gains at expense of short-term losses*—Discuss positive aspects of the proposed action on a long-term basis and compare these with detrimental short-term effects. For example, construction of a sewage treatment plant may result in activities which create noise, dust, or erosion, but long-term aspects of the project include enhanced water quality in the receiving stream.

c. *Extent to which proposed action forecloses future options*—Assess the cumulative and long-term impacts of the proposed action with the view that each generation is a trustee of the environment for succeeding generations. Consider such losses as restrictions on visitations of historic or archeological sites, destruction of natural vistas, or increased danger to threatened species.

7. *Irreversible and Irretrievable Commitments of Resources*

This section identifies irrevocable effects on resources that would be involved in the proposed action should it be implemented. This is accomplished by a review of the discussion under Point 5 and specifically identifying *unavoidable impacts that irreversibly curtail the range of potential uses of the environment.*

In discussing resources committed to loss or destruction by the action, the term "resources" should include the following meanings:

(1) *Labor*—Discuss the labor requirements for the proposed action and the degree to which the expenditure of this labor force would detract from other areas of productivity.

(2) *Materials*—Discuss the use of materials in short supply (e.g., fuels, wood and scarce metals) but do not include materials which are plentiful or have competitive alternatives (e.g., aggregate, fill material).

(3) *Natural*—Discuss the irrevocable use of natural resources resulting in effects such as ecosystem imbalance, destruction of wildlife habitats, or loss of natural land-use patterns. Specifically include consumption of natural energy resources in short supply such as oil or natural gas.

(4) *Cultural*—Discuss destruction of human-interest sites, archeological sites, scenic views, or open space where such space is limited. Reiterate lasting social or economic effects that proposed action might have on the surrounding community.

8. *Other Interests and Considerations of Federal Policy That Offset the Adverse Environmental Effects of the Proposed Action*

This section is designed specifically to call attention to positive aspects of the proposed action that might offset the negative effects brought out earlier in the discussion of Point 3 and Point 5. The benefits of the proposed action should be addressed in the following manner:

a. *Countervailing benefits of the proposed action*—Discuss positive aspects of the action in order that positive effects may be weighed against negative environmental effects.

b. *Countervailing benefits of alternatives*—Discuss the extent to which the benefits stated in a. could be realized by following reasonable alternatives (identified under Point 4) that would avoid some or all of the adverse environmental effects. If a cost-benefit analysis has been prepared for the proposed action, it should be attached. However, the extent to which environmental costs have or have not been reflected in

the analysis should be clearly indicated.

EIA AND EIS PROCESSING

After the environmental impact assessment or statement has been prepared, processing of the document depends primarily on whether the document is (1) an assessment, (2) a draft statement, or (3) a final statement.

Assessments

If an environmental assessment is made and it is determined that no statement is required, documentation, processing, and other follow-on procedures may vary with command, subject to conformance with the DA guidance from AR 200-1. For example, FORSCOM Reg. 420-5 requires that written environmental assessments be prepared for field exercises by the proponent of the exercise and that copies of the assessments be forwarded to HQ FORSCOM. TRADOC Reg. 420-5, on the other hand, requires that assessments for field exercises become a part of the training file. Other environmental assessments for both commands are to be filed on a permanent basis at the installations and will be reviewed and verified for adequacy during staff visits by HQ representatives of the specific command installations.

In summary, if an assessment has been made and it is determined that no statement is required, procedures for processing the assessment are based on guidance issued by the proponent command or HQDA.

Draft Statements

If it is determined that an environmental impact statement is required, the next step is the preparation and processing of a draft environmental impact statement. As in the case of written assessments, processing procedures vary slightly with command, and specific guidance from the proponent command or HQDA should be consulted.

Final Statements

After the draft environmental impact statement has undergone the review process, the final statement is prepared and processed. Processing procedures for final statements vary slightly with command. Guidance issued by the proponent command or Headquarters DA should be consulted.

Public Participation

In many phases of its operation, the Army has impact upon local communities. Activities of construction engineering units such as the Corps of Engineers, as well as the development and existence of major military operations, have major effects upon surrounding, recipient civilian communities.

Therefore, it is the Army's responsibility to insure that local citizens and communities are impacted as little as possible. If done effectively, such programs can foster a supportive and receptive local political environment in which to operate, and it is further in the best interest of the Army to conduct effective programs of community involvement.

Effective Community Participation

Effective community participation has been defined as a community acting with full information, equal access to decision-making institutions, and implementing its jointly articulated objectives.* Based on this definition, several important objectives should be achieved to attain effective participation in Army projects.

First, there must be as much information as possible made available to the public. There often is considerable misinformation about the nature of most proposed projects even when they do not involve withholding of information affecting national security. This lack of communication precludes effective citizen participation in many cases.

The Army often allows its image as a public spirited service institution to be maligned. This is accomplished by organizations and individuals who construe the Army's failure to provide adequate information as cavalier or inconsiderate. If instead an active program of public information and public participation were undertaken, not only would there be more useful public input, and therefore a better project, but there would probably be less criticism of the Army.

Possible Techniques

All Federal agencies are encouraged by CEQ to establish procedures for public participation beyond the standard format of public hearings. These may range from informal, unstructured contacts with community and environmental leaders to more formal panels of advisors on NEPA issues or clearinghouses for citizen inputs into the impact statement commenting process. There are many public involvement techniques available with varying capabilities to accomplish objectives, as shown in Figure 2.6.

Benefits to the Army

Several possible benefits can be realized when broader programs of public participation are undertaken. There is a greater likelihood that several more viable or innovative alternatives can be identified from the diverse perspectives of the community that is well aware of its resources.

There is further possibility that there might be a closer integration of Army planning and development with existing area planning efforts in which the public should already have made a major input. The public reacts unfavorably when its previous input to other pertinent plans is summarily disregarded by Army planners and decision makers.

Third, active public involvement can also insure that the final product, which the community helps to develop, will be successfully implemented. Implementation is much more likely where the community has taken an active concern in planning problems, and has played an important role in generating and evaluating alternative solutions. An important spinoff from a positive program of public involvement would be a positive public attitude toward not only the proposed project, but toward the Army as well.

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*Manty, Dale, *et al.*, "Conceptual Framework for Effective Community Participation." A report to the Battelle Urban and Regional Development Program (in progress).

Communication Characteristics			Public Participation Techniques	Planning Objectives					
Degree of 2-Way Communication	Level of Public Contact Achieved	Ability to Handle Specific Interest		Inform/Educate	Identify Problems/ Values	Get Ideas/Solve Problems	Feedback	Evaluate	Resolve Conflict/ Consensus
2	1	1	Public Hearings		X		X		
2	1	2	Public Meetings	X	X		X		
1	2	3	Informal Small Group Meetings	X	X	X	X	X	X
2	1	2	General Public Information Meetings	X					
1	2	2	Presentations to Community Organization	X	X		X		
1	3	3	Information Coordination Seminars	X			X		
1	2	1	Operating Field Offices		X	X	X	X	
1	3	3	Local Planning Visits		X		X	X	
1	3	1	Class Action Litigation	X		X	X		X
2	2	1	Information Brochures and Pamphlets	X					
1	3	3	Field Trips and Site Visits	X	X				
3	1	2	Public Displays	X		X	X		
2	1	2	Model Demonstration Projects	X			X	X	X
3	1	1	Material for Mass Media	X					
1	3	2	Response to Public Inquiries	X					
3	1	1	Press Releases Inviting Comments	X			X		
1	3	1	Letter Requests for Comments			X	X		
1	3	3	Workshops		X	X	X	X	X
1	3	3	Charettes (Intensive decision-making, setting)			X		X	X
1	3	3	Advisory Committees		X	X	X	X	
1	3	3	Task Forces		X	X		X	
1	3	3	Employment of Community Residents		X	X			X
1	3	3	Community Interest Advocates			X		X	X
1	3	3	Ombudsman or Representative		X	X	X	X	X
2	3	1	Environmental Impact Statement Review by Public	X			X	X	

1 = Low; 2 = Medium; 3 = High

FIGURE 2.6. CAPABILITIES OF PUBLIC PARTICIPATION TECHNIQUES

CHAPTER 3

ENVIRONMENTAL IMPACT AND ARMY ACTIVITIES

Discussed in this chapter are the elements of the impact assessment matrix, environmental attributes, and Army activities. Included also are the impact analysis work sheets and a form to summarize impacts.

THE IMPACT ASSESSMENT MATRIX

For every Army activity there exists the possibility that one of the attributes of the environment will be affected in a positive or a negative way. In this framework, Army activities have the potential for impacting all of the various environmental resources. Some of the environmental elements may be affected more than others, but this is to be determined only after the characteristics of the Army activity have been identified. The individual preparing the impact assessment or statement would define the Army activity in as great a detail as is warranted to identify possible environmental impact. Then the individual would review, item by item, the various environmental attributes, using the detailed write-ups on these attributes (presented in Appendix A) to assess the potential effect of the Army activity on each attribute. To facilitate this process, a sample matrix should be used to insure that all attributes are reviewed. Figure 3.1 is a simplified matrix that illustrates categories of attributes on one axis and major Army activities on the other axis. If the user makes an entry indicating the extent of impact next to each attribute, he will be certain to have reviewed them all. The process of reviewing each attribute separately should be accomplished for the subject Army activity and for the selected viable alternatives to that activity where appropriate.

THE ENVIRONMENTAL ATTRIBUTE

Figure 3.2 lists the various environmental attributes to be considered in preparing an EIA or EIS. Each of the 46 attributes is discussed in Appendix A. While reading these attributes, Figure 3.2 can be used to make notes relating the attributes to the typical projects for which the user utilizes the handbook. The characteristics of the attribute and methods for determining the impact on it are given. The attribute descriptor package is presented in a standardized order and format (see Figure 3.3) to facilitate use of the information in assessing impacts.

Army Activities	Environmental Attributes					
	Air	Water	Land	Ecology	Sound	Socioeconomic
Construction						
Operation, Maintenance and Repair						
Training						
Mission Change						
Real Estate						
Procurement						
Industrial Activities						
Research, Development, Test, and Evaluation						
Administration and Support						

FIGURE 3.1. ENVIRONMENTAL IMPACT MATRIX

Category	No.	Attribute	No.	Attribute
Air	1	Diffusion factor	6	Carbon monoxide
	2	Particulates	7	Photochemical oxidants
	3	Sulphur oxides	8	Hazardous toxicants
	4	Hydrocarbons	9	Odor
	5	Nitrogen oxide		
Water	10	Aquifer safe yield	17	Biochemical oxygen demand
	11	Flow variations	18	Dissolved oxygen (DO)
	12	Oil	19	Dissolved solids
	13	Radioactivity	20	Nutrients
	14	Suspended solids	21	Toxic compounds
	15	Thermal pollution	22	Aquatic life
	16	Acid and alkali	23	Fecal coliform
Land	24	Erosion	26	Land use patterns
	25	Natural hazard		
Ecology	27	Large animals (wild and domestic)	31	Field crops
	28	Predatory birds	32	Threatened species
	29	Small game	33	Natural land vegetation
	30	Fish, shell fish, and water fowl	34	Aquatic plants
Sound	35	Physiological effects	38	Performance effects
	36	Psychological effects	39	Social behavior effects
	37	Communication effects		
Human	40	Life styles	42	Physiological systems
	41	Psychological needs	43	Community needs
Economic	44	Regional economic stability	46	Per capita consumption
	45	Public sector revenue		

FIGURE 3.2. ENVIRONMENTAL ATTRIBUTE LISTING

Attribute Name	
Definition of The Attribute	Evaluation and Interpretation of Data
Army Activities That Affect The Attribute	Special Conditions
Source of Effects	Geographical and Temporal Limitations
Variables to be Measured	Mitigation of Impact
How Variables Are Measured	Other Comments
Additional References	

FIGURE 3.3. ATTRIBUTE CHARACTERIZATION
(as Presented in Appendix A)

Description

The following paragraphs delineate the rationale for the items included in characterizing the attributes.

Definition of the Attribute

This item defines the environmental attribute. The definition also explains how the attribute relates to the environment.

Army Activities That Affect the Attribute

This item contains *examples* of Army activities and suggests what type of activity affects the subject attribute.

Source of Effects

This item provides a brief discussion of some of the potential ways Army activities will cause an impact on the subject environmental attribute.

Variables to Be Measured

This item discusses the real world variables that are to be measured to indicate environmental impact. If necessary, the relationship of the measurement to the attribute is also discussed.

How Variables Are Measured

This is one of the most important items in the attributes write-up. To the extent possible, the methods for measuring impact on the variables are presented here. This includes information on sources of data that can be used to assist in measuring impact. These sources are primarily secondary data sources. References to additional technical materials that are required to adequately measure changes in the variables may be included. The types of skills that may be required in measuring impact on the variables are also discussed. For example, for collecting census data from published reports, no special skill is required; but for measuring sound levels, detailed technical capabilities may be required. The need for these capabilities is identified in this item. To the extent that special instruments for measuring impact are required, they are

identified and sources for obtaining these instruments are given.

Evaluation and Interpretation of Data

Once the data regarding impact have been collected, an additional step is required to determine whether the impact on the subject attribute is favorable or unfavorable. In addition, the evaluation of the severity of impact is also discussed. For some attributes, the method for converting the changes in the variable into another indicator of impact is presented. This permits comparison to other environmental attributes. Other attributes are not as easily evaluated, and evaluation of the impact may require considerable professional expertise.

Special Conditions

This item discusses the special measurement problems or difficulties that may be encountered in determining the impact on the subject attribute. These special conditions stem from poor availability of secondary data. If necessary, this item discusses the type and necessity for special measurement techniques. Examples of the special conditions would be the necessity for survey data regarding community values to provide baseline data for some of the impacts in the human-environment category. Another example would be the need for extremely complicated measurement instruments the use of which may be beyond the capability of the user of the manual.

Geographical and Temporal Limitations

Discussed are the potential problems that might arise because of different geographic or time locations of impacts on the attribute. For example, many of the land attributes will have varying impacts depending on the geographical location of the subject activity.

Mitigation of Impact

Each environmental attribute has the potential for being affected by Army activities. However, it is also possible for the activities to be modified in such a way as to reduce the impact on the attributes. The methods for reducing impact are discussed in the activity to the application of special equipment to reduce impact on the environment.

Other Comments

This item is reserved for information that does not fall within any of the other items relating to the environmental attributes.

Additional References

This space provided in the handbook may be utilized by the user for additional references relevant to his activity. For example, specific information for data sources, points of contact, etc., for use in future project assessments may be added in this section.

Procedure for Using the Attribute Descriptor Package

The evaluation of environmental impact on an attribute-by-attribute basis is a straightforward review of each of the attribute write-ups keeping in mind the potential Army activity that may cause the impact. As the attributes are reviewed, the data collected, and the impacts identified, entries should be made in the environmental attribute list to indicate the potential impact of the Army activity on the environment.

ARMY ACTIVITIES

One dimension of the impact assessment matrix is environmental attributes. The other dimension of the matrix is Army activities that can be broadly classified into nine major categories:

- Construction
- Operation and maintenance
- Training
- Mission change
- Real estate
- Procurement
- Industrial activities
- Research, development, test and evaluation
- Administration and support.

Each of these broad activities can be divided into a series of detailed actions. This section is presented to provide the user of the manual with a relatively detailed listing of actions that might impact on the environment.

The detailed listing has been reduced to those actions that are likely to cause environmental impact. However, the identification of actions that have the greatest potential for environmental impact does not preclude the need to be alert to unique actions which are potential significant impactors on the environment. Furthermore, should a project fall within the list of activities, the user is responsible for careful consideration of the potential for significant impact.

The categories of activities are *not* to be considered mutually exclusive. In fact, most major programs or projects to be assessed will involve two or more of the activities listed. For example, the activation of an airfield could involve construction; operation, maintenance and repair; training; and administration and support.

Construction

Due largely to their highly visible nature, construction projects and construction-related activities maintain a high priority in the realm of environmental impact assessment. Thus, the military construction program places the Army in a position of responsibility for the utilization of vast amounts of manpower, materials, and equipment. In the process of accomplishing construction objectives, there exists the potential to induce socioeconomic changes as well as impact on the biophysical environment.

The activities presented herein correspond to the sequence of activities normally followed in construction operations. Occurrence and magnitude of activities are, of course, highly project specific.

Construction Activities

Site Access/Delivery
- Railroad
- Road
- Water
- Air
- Pipeline

Support Facilities Operation
- Asphalt plant
- Aggregate production
- Concrete operations
- Foundry & metal shop
- Fuel storage and dispensing
- Material storage
- Personnel support
- Utilities provision
- Solid waste disposal
- Sewage disposal

Site Preparation
- Clearing and grubbing
- Tree removal
- Existing structure removal
- Demolition debris disposal

Excavation
- Topsoil stripping
- Excavation
- Backfill
- Channeling and Dredging
- Hauling

Quarrying & Subsurface Excavation
- Cutting and drilling
- Loosening
- Hauling
- Drainage

Foundations (Buildings and Roads)
- Base course
- Footings
- Compaction
- Piling
- Foundation Mats
- Groundwater control

Bituminous Construction
- Hauling
- Mixing
- Placing and spreading
- Compaction
- Curing and sealing

Concrete Construction
- Hauling
- Mixing
- Placing
- Finishing

Masonry Construction
- Hauling
- Forming
- Mortar mixing
- Placing
- Finishing

Steel Construction
- Hauling
- Erecting
- Finishing

Timber Construction
- Hauling
- Pest/Insect protection
- Cutting and shaping
- Erecting
- Finishing

Finishing—General
- HVAC (heating, ventilating and air conditioning)
- Electrical
- Plumbing
- Cleanup operations
- Landscaping
- Painting

Operation and Maintenance

Under this functional area there are two major programs: (1) operation and (2) maintenance.

Activities associated with operation and maintenance are similar to activities associated with running a small city. The activities are grouped into categories descriptive of their nature (which make them unique) and related to the Army accounting system (to make them more accessible).

Operation, Maintenance, and Repair Activities

Building Repair
- Woodworking
- Roofing
- Concrete & masonry
- Electrical System
- HVAC

Road Repairs
- Soil and material handling
- Resurfacing

Building Demolition

Channel Dredging

Metal Working

Repair of Combat-Associated Materials
- Ordnance
- Aircraft
- Missiles
- Ships
- Vehicles
- Communications equipment

Base Operations O & M [AR37-100-74 Z Accounts]
- Aircraft
- Automotive equipment (C1B00)
- Combat vehicles (C1C00)
- Construction equipment (C1D00)
- Electronic & communication equipment (C1E00)
- Missiles (C1F00)
- Ships (C1G00)
- Weapons (C1I00)

General equipment (C1K00)
Commodity groups (C1L00)
Plant equipment (C3000)
Radio and T.V. facilities (G2100)
Newspapers (G2200)
Issue commissaries (H4100)
Garrison bread bakeries (H4200)
Dining facilities (H4400)
Central pastry kitchen (H4500)
Commissary stores (H4600)
Laundry and dry cleaning services (H5000)
Hospital and medical facilities (K2500)
Communication services (H1000)
Photographic services (H2100)
Administrative rail services (H3300)
Water service (J1000, K1100, K1130)
Water treatment system (J1200, K1110)
Sewage services (J000, K1200)
Industrial waste treatment facilities (J2300, K1214)
Electrical service (J3000, K1300)
Boiler and heating plants (J4000, K1400)
Cold storage and air conditioning plants (J5000, K1500)
Buildings (K2000)
Grounds maintenance (K3000)
Maintenance other than improved grounds (K3200)
Surfaced areas (K5000)
Marine facilities (See K6000)
Special equipment maintenance (K6000)
Inactive facilities maintenance (K8000)
Fire prevention and protection (M1000)
Refuse handling (M2000)
Pest control services (M3000)
Custodial support (M4000)
Snow removal and ice alleviation (K5000)
Dependents schools (N2100)
Data processing centers (N2300)

Family Housing
Utility operations and maintenance
Refuse collection and disposal
Maintenance of exteriors
Maintenance of interiors

Transportation Services O&M
Material storage
Transfer facilities
Traffic

Training

For training activities three programs have been identified: (1) support activities, (2) academic training, and (3) practical training.

Support activities include those activities associated with the quartering, feeding, and movement of individuals during training. The scale of support is dependent upon the number of personnel involved.

Academic training is essentially classroom instruction and is carried out in conjunction with the practical training program.

The practical training program for an individual progresses from Basic Combat Training (BCT) to Advanced Individual Training (AIT) and finally to Unit Training or Specialty School. There are three levels of Unit Training—Basic Unit Training (BUT); Advanced Unit Training (AUT); and Operational Readiness Training (ORT).

Training Activities

Support Activities Program

- Quartering in Government facilities
  - Bivouac
  - Cantonment
  - Water supply
  - Waste disposal
  - Heating
- Quartering in commercial facilities

- Feeding personnel at Government facilities
  - Bivouac
  - Mess hall
- Feeding personnel at commercial establishments

- Movement of personnel and/or equipment
  - Established routes
  - Cross country
  - Commercial carriers
  - Watercraft
  - Rotary wing aircraft
  - Fixed wing aircraft
  - Amphibious vehicles
  - Air drops
- Assembly area maintenance

Academic Training Program

- Mechanical orientation and nomenclative training
- Electrical (electronic) orientation nomenclative training
- School of the soldier
- Administrative and support training
- Medical training
- Safety orientation and nomenclative training
- Security training

Practical Training Program
- Weapons training
  - Small arms
  - Artillery
  - Missiles
  - Explosives
  - Other weapons
- Vehicle operation and maintenance
- Technical training (communications, etc.)
- Physical training
- Tactical training
  - Escape and evasion
  - Camouflage
  - Defense emplacement (field fortifications)
  - Urban warfare
  - Infiltration course
  - Assault
  - Riot control

Mission Change

Mission statements for elements of the Army are essentially scopes of work. They state what, where, sometimes when, and by whom particular objectives are to be accomplished. Actions are carried out to satisfy the requirements of the mission statement under each functional area previously discussed. Assessment of the impact of these actions is the responsibility of the commanding officer. However, changes in the mission will alter their impact. There are obviously policy and political implications in the activities for mission change.

Changes in personnel strength are often directed from higher headquarters. In general, a directive will stipulate that the existing work force must be reduced a certain percentage (or approval is given to a request for an increase). For a reduction, the alternatives are to allow a strength to slip by attrition through retirement and resignation or to layoff individuals to achieve the necessary strength. Usually it is up to the individual command to decide on the mode of reduction of troop strength, civilian strength, or a combination thereof. Reductions (or increases) in grade structure are again usually directed and may be met by filling the remaining job slots with lower grade personnel, reducing the grades of existing personnel, or removal of existing personnel by transfer, resignation, attrition, or layoffs.

Alteration of a job type is usually a consequence of addition or deletion of a function. This results in a different kind of individual required to complete the mission. Alteration of the job qualification is generally by specification. Alteration of the physical constraints is again generally by specification in that the requirements for specific health, age, or sex limits to perform a certain job are changed.

Addition or deletion of a function is always by direction of higher headquarters. This is often reflected in an increase or decrease in output such as the quantity of product or the number of students in a school.

The following considerations must be given to mission-change activities:

A. Where:
   1. Location of activity

2. Regional influence of activity

The location of an activity or a regional sphere of influence of an activity is designated by higher headquarters. Examples of change of location of activity are transfer of the 82nd Airborne Division from Fort Benning, Georgia, to Fort Bragg, North Carolina; transfer of the training function of military intelligence from Fort Holabird, Maryland, to Fort Huachuca, Arizona; and transfer of the Paint and Corrosion Technology Laboratory from Rock Island Arsenal to Picatiny Arsenal. An example of a change of regional influence of an activity is the consolidation of the Fourth and Fifth Army Medical Laboratories at Fort Sam Houston, Texas, to cover all of the area of responsibility initially covered by these laboratories separately.

B. When:

1. Rapidity with which activities are implemented
2. Duration of change
3. Frequency of change

The rapidity with which these actions might take place ranges from a few months for small activities to over a year or more for closing an installation. The duration of a change may be permanent, such as the closing of an installation, or short term, such as increases or decreases in production or manpower strength. The frequency of change is often dictated by outside influences such as political climate.

Mission Change Activities

Change in personnel strength
Change in grade structure or rank
Alteration of job
Alteration of job qualifications
Alteration of physiological constraint (age, sex, health)
Change in a function or task

Real Estate

Most of the activities associated with the real-estate functional area should be considered policy actions; that is to say, policy actions are intangible actions such as a decision to buy land, while an actual activity would be clearing brush or maneuvering a vehicle. In some cases, policy actions can result in substantially more widespread environmental impacts than activities. For example, a decision to reduce Army nationwide expenditures by 30 percent would result in substantial economic disruptions across the nation. On the other hand, clearing the brush from a construction site might have only local watershed implications.

Real-estate activities are divided into four areas: (1) real-estate acquisition, (2) real-estate disposition, (3) outleases of land, and (4) sale of timber products from Army-owned land.

Real Estate Activities

Real Estate Acquisition

By purchase
By condemnation
By lease
By donation
By transfer from other Government agencies

Real Estate Dispositions
- To Governmental agencies
- To the public

Outleases of land
- For grazing
- For crops
- For mineral extraction

Sale of Timber
- Overstory removal
- Sanitation cut
- Thinning
- Clear cutting
- Reforestation

Procurement

Procurement encompasses four categories: (1) principal items (e.g., aircraft, missiles), (2) secondary items (e.g., parts, supplies, food for mess halls), (3) utilities and services, and (4) nonappropriated funds (e.g., purchases for service clubs, commissaries, post exchanges).

Procurement in the first three categories is accomplished in accordance with the Armed Services Procurement Regulations (ASPR). These regulations establish for the Department of Defense, uniform policies and procedures relating to the procurement of supplies and services under the authority of Chapter 137, Title 10, of the United States Code, or under other statutory authority. These regulations apply to all purchases and contracts made by the Department of Defense, which obligate appropriated funds (including available contract authorizations), unless otherwise specified. Transportation services procured by transportation requests, transportation warrants, bills of lading, and similar transportation forms are not included.

Nonappropriated fund activities (e.g., open mess, welfare fund, chaplains funds) are not technically required to follow ASPR in their procurement activities. For nonappropriated funds the procurement is by bid or by negotiation.

Procurement activities have potential for environmental impact. They can affect the biophysical environment directly and these effects can also be consequences resulting from socioeconomic changes produced by the procurement action. This becomes apparent when secondary effects such as manufacturing processes, resource consumption, and transportation are considered.

Procurement Activities

Principal Items
- Aircraft
  - Fixed wing
  - Rotary wing
- Weapons
  - Crew-served
  - Individual
  - Artillery
  - Tracked combat vehicles

Missiles
Ammunition
Other procurement

Secondary Items
Procurement, Army-Secondary Items
Stock Fund Items
From other Government agencies (GSA, etc.)
Local procurement

Procurement of Utilities and Services from Civilian Sector
Utilities
Services

Nonappropriated Fund Activities
Personnel support
Food oriented
Non-food oriented
Post exchange

Industrial Activities

Under this functional area three programs or categories are identified: depots, arsenals, and the government-owned, contractor-operated (GOCO) production base (primarily ammunition plants).

Depots are government-owned, government-operated facilities under the control of the U.S. Army Materiel Command (AMC). Depots serve two distinct functions—storage and repair. Each depot has a primary commodity storage assignment and at least one secondary storage assignment. The repair facilities can best be described as small-lot assembly line operations.

U.S. Army Arsenals are generally government-owned, government-operated facilities under the Army Materiel Command (AMC). Historically, they were established for the manufacture, storage, and repair of weapons, and the storage of ammunition and supplies for support of weapons. The arsenal activities have had a change in emphasis in recent times. Storage and repair of most weapons as well as most ammunition have been transferred to depots. Weapons-manufacturing capability still exists at the arsenals, and periodically some weapons manufacturing or repair contracts are fulfilled at arsenals. Today, however, most weapons are procured from the commercial sector by contract. Consequently, the arsenals have been assigned an R&D role.

The largest portion of the government production base consists of approximately 20 active ammunition GOCO plants under the management of the Army Armament Command (ARMCOM), one of the major subordinate commands reporting to the Army Materiel Command. Eighty percent of the explosives used by the U.S. Armed Forces are produced by these plants. In addition, some of these plants produce major components and end items of ammunition. The other major subordinate commands also have a few plants which are part of the base, such as the Tank and Automotive Command's Detroit Arsenal Tank Plant, the Missile Command's Redstone Arsenal, and the Michigan Army Missile Plant.

Most contracts with the contractor are multi-year agreements which call for the maintenance of the physical plant throughout the life of the contract and contain only

the first year's munitions production levels. Successive years' production schedules are accomplished as amendments to the basic contract. Among plants producing the same product, a modified bidding procedure (similar to that between depots) is carried out to determine the supplier of the particular quantity requirement. Procurement of the raw materials for ammunition production is a responsibility of the contractor. Procurement is made from the civilian economy and is technically independent of ASPR.

Industrial Activities

Depot Supply Activities
- Transportation activities
- Utilities usage
- Storage and warehousing
- Cleaning (acids, alkalines, solvents, abrasives, etc.)
- Drying (draining, ovens, etc.)
- Preservation (paint, corrosion inhibitors, etc.)
- Packing and issue

Depot Maintenance Activities
- Transportation activities
- Disassembling operations
- Disposal of waste petroleum products
- Detread and retread tires and tank road wheels
- Metal surface treating (other than plating)
- Plating operations
- Machining operations
- Welding operations
- Painting operations
- Repair items
- Test repaired items

Arsenal Activities — General
- Transportation activities
- Utilities usage
- Material storage
- Manufacturers' facilities
- RDTE facilities

Manufacture Weapons
- Foundry operations
- Machine shop operations
- Heat treating
- Metal finishing

Demilitarize Weapons
- Conventional ammunition/explosives
- Chemical munitions
- Other demil operations

Ammunition Plants — General
- Transportation activities

Utilities usage
Material storage

Ammunition Plant Activities
Quality control
Manufacture detonating agents
Manufacture priming compositions
Manufacture noninitiating high explosives
Manufacture propellants
Manufacture shell casings
Manufacture projectiles
Load, assemble, and pack explosive munitions

Manufacture Chemical Agents
Choking agents
Nerve agents
Blood agents
Blister agents
Vomiting agents
Tear agents

Manufacture Chemicals for Use in Explosives Manufacture
Nitric acid
Sulfuric acid
Acetic Anhydride

Disposal of Spent and Off-Specification Material

Research, Development, Test and Evaluation [RDTE]

Details of much of this work are classified (see AR 200-1). A list of likely activities was generated by personnel with some knowledge of the general area, but lacking privileged information from any Army facilities. The list of activities includes most common predictable activities. The remainder of the list of RDTE activities consists of a group of common testing procedures known to be used in many installations. Many of the items are admitted to have several meanings in a broad range of disciplines, and this variety of meanings should be taken into account in evaluating impacts.

RDTE Activities

Chemical and Biological Research
Basic laboratory research
Material disposal
Waste disposal
Laundry
Semiworks—pilot plant development
Operate semiworks
Waste disposal
Proving ground
Agent disposal
Waste disposal
Site contamination

Testing Programs

- Abrasion tests
- Acceleration tests
- Corrosion tests
- Crash tests
- Cross-country tests
- Destructive tests
- Firing tests (ordnance)
- Flight tests
- Full scale tests
- Impact tests
- Mechanical tests
- Missile tests
- Nondestructive tests
- Chemical tests
- Core tests
- Performance tests
- Physiological tests
- Propellant tests
- Psychological tests
- Radiation tests
- Shock tests
- Soil tests
- Static tests
- Ultrasonic tests
- Vibration tests
- X-ray inspection

Administration and Support

Administration and support, as one might expect, include those functions which are required to make a facility, office, or organization function in a coherent manner. Many of the activities of administration and support are covered under other functional areas.

Administration and Support Activities

Executive Office Actions

- Issuance of orders and guidance
- Personnel actions
- Public communications

Personnel Services

Information Manipulation

Services

- Legal
- Library
- Mail
- Veterinarian

Army Activities Likely to Have Significant Impact

A representative list of Army actions which might have a significant environmental impact or for which the impact forecasted might be considered environmentally controversial is included in Chapter 2 and AR 200-1.

ADDING UP

There are a variety of ways that impact on the environment can be presented to indicate the total impact of the subject activity. One way to do this is to assign numbers to the impact and then to add the numbers over all attributes. The virtue of this approach is that it provides a single number to indicate total environmental

impact; its drawback is that the single number masks the distribution of the impact among the attributes. It does not give the decision maker any feel for the severity of impact on specific attributes and does not provide him any basis for determining whether an alternative reduces severity of impact on a particular attribute. Another approach to summarizing impacts is to provide a nonnumerical indicator of impact on an attribute-by-attribute basis. Unless the indicator is consistent from attribute to attribute, it is very difficult for an individual reviewing a series of alternative activities to draw any conclusions regarding the comparative overall impact.

The approach adopted for presentation of results from this manual is to indicate both the direction, positive or negative, and severity of impacts on all attributes in a single diagram. It is possible to conjecture about the relative importance of impact on one attribute as compared to another attribute. To avoid the problems that arise from making judgment about the relative importance of attributes, all attributes identified in this study are assumed to be of equal importance. It should be pointed out, however, that in the process of identifying the important attributes in each major area of the environmental impact, it was not required that each attribute be of equal importance.

A bar chart similar to the one in Figure 3.4 is recommended as a summary instrument for presenting the results of the environmental impact assessment on an attribute-by-attribute basis. Using the key shown in Figure 3.4, environmental impacts can be summarized from Impact Analysis Worksheet onto this summary sheet.

Providing equal weight to all environmental attributes makes it the responsibility of the individual reviewing alternative projects to implicitly decide which of the environmental attributes is more important than another. It is possible to provide an ordinal ranking of environment attributes where the ranking is based on the opinion of experts in the various attribute categories. It is almost inevitable that this ranking of attributes will be inconsistent with the preferences of the agency group or community that compares the alternative projects that may take place in the area. In addition, ranking of the attributes may vary from one geographical region to another, and in addition the ranking may vary over time. Because of these complications, the attributes are assumed to be of equal weight. The attributes are grouped according to environmental categories.

Category		Attribute Number	Attribute	*Net Positive Impact +	Net Negative Impacts X
Socioeconomic	Economic	46	Per capita consumption		
		45	Public sector revenue		
		44	Regional economic stability		
	Human	43	Community needs		
		42	Physiological systems		
		41	Psychological needs		
		40	Life styles		
Sound		39	Social behavior effects		
		38	Performance effects		
		37	Communication effects		
		36	Psychological effects		
		35	Physiological effects		
Ecology		34	Aquatic plants		
		33	Natural land vegetation		
		32	Threatened species		
		31	Field crops		
		30	Fish, shell fish, and water fowl		
		29	Small game		
		28	Predatory birds		
		27	Large animals (wild and domestic)		
Land		26	Land use patterns		
		25	Natural hazard		
		24	Erosion		
Water		23	Fecal coliform		
		22	Aquatic life		
		21	Toxic compounds		
		20	Nutrients		
		19	Dissolved solids		
		18	Dissolved oxygen (DO)		
		17	Biochemical oxygen demand		
		16	Acid and alkali		
		15	Thermal pollution		
		14	Suspended solids		
		13	Radioactivity		
		12	Oil		
		11	Flow variations		
		10	Aquifer safe yield		
Air		9	Odor		
		8	Hazardous toxicants		
		7	Photochemical oxidants		
		6	Carbon monoxide		
		5	Nitrogen oxide		
		4	Hydrocarbons		
		3	Sulphur oxides		
		2	Particulates		
		1	Diffusion factor		

Project Name ________

Project Number ________

Alternative ________

☐ No Significant Impact

▧ Moderate Impact

▩ Significant Impact

*Positive impacts are shown above the attribute number and negative impacts below.

FIGURE 3.4. SUMMARY OF IMPACTS

IMPACT ANALYSIS WORKSHEET

ACTIVITIES \ ENVIRONMENTAL ATTRIBUTES	AIR									WATER																	LAND			ECOLOGY										SOUND				SOCIO ECONOMIC				COMMENTS
																																											HUMAN			ECONOMIC		
	Diffusion factor	Particulates	Sulphur oxides	Hydrocarbons	Nitrogen oxide	Carbon monoxide	Photochemical oxidants	Hazardous fractions	Odor	Aquifer safe yield	Flow variations	Oil	Radioactivity	Suspended solids	Thermal pollution	Acid and alkali	Biochemical oxygen demand	Dissolved oxygen (DO)	Dissolved solids	Nutrients	Toxic compounds	Aquatic life	Fecal coliform	Erosion	Natural hazard	Land use patterns	Large animals (wild and domestic)	Predatory birds	Small game	Fish, shell fish and water fowl	Field crops	Threatened species	Natural land vegetation	Aquatic plants	Physiological effects	Physiological effects	Communication effects	Performance effects	Social behavior effects	Life cycles	Physiological needs	Physiological systems	Community needs	Regional economic stability	Public sector revenue	Per capita consumption	
CONSTRUCTION																																														
Site Access/Delivery																																														
Railroad																																														
Road																																														
Water																																														
Air																																														
Pipeline																																														
Support Facilities Operation																																														
Asphalt plant																																														
Aggregate production																																														
Concrete operations																																														
Foundry & metal shop																																														
Fuel storage and dispensing																																														
Material storage																																														
Personnel support																																														
Utilities provision																																														
Solid waste disposal																																														
Sewage disposal																																														
Site Preparation																																														
Clearing and grubbing																																														
Tree removal																																														
Existing structure removal																																														
Demolition debris disposal																																														
Excavation																																														
Topsoil stripping																																														
Excavation																																														
Backfill																																														
Channeling and Dredging																																														
Hauling																																														
Quarrying & Subsurface Excavation																																														
Cutting and drilling																																														
Loosening																																														
Hauling																																														
Drainage																																														
Foundations (Buildings and Roads)																																														
Base course																																														
Footings compaction																																														
Piling																																														
Foundation Mats																																														
Groundwater control																																														
Bituminous Construction																																														
Hauling																																														
Mixing																																														
Placing and spreading																																														
Compaction																																														
Curing and sealing																																														
Concrete Construction																																														
Hauling																																														
Mixing																																														
Forming																																														
Placing																																														
Finishing																																														
Masonry Construction																																														
Hauling																																														
Mortar mixing																																														
Placing																																														
Finishing																																														
Steel Construction																																														
Hauling																																														
Erecting																																														
Finishing																																														
Timber Construction																																														
Hauling																																														
Pest/Insect protection																																														
Cutting and shaping																																														
Erecting																																														
Finishing																																														
Finishing -- General																																														
HVAC																																														
Electrical																																														
Plumbing																																														
Cleanup operations																																														
Landscaping																																														
Painting																																														

FIGURE 3.5. IMPACT ANALYSIS WORK SHEETS

IMPACT ANALYSIS WORKSHEET

ACTIVITIES / ENVIRONMENTAL ATTRIBUTES	AIR									WATER														LAND			ECOLOGY								SOUND					SOCIO ECONOMIC: HUMAN				SOCIO ECONOMIC: ECONOMIC			COMMENTS
	Diffusion factor	Particulates	Sulphur oxides	Hydrocarbons	Nitrogen oxide	Carbon monoxide	Photochemical oxidants	Hazardous toxicants	Odor	Aquifer safe yield	Flow variations	Oil	Radioactivity	Suspended solids	Thermal pollution	Acid and alkali	Biochemical oxygen demand	Dissolved oxygen (DO)	Dissolved solids	Nutrients	Toxic compounds	Aquatic life	Fecal coliform	Erosion	Natural hazard	Land use patterns	Large animals (wild and domestic)	Predatory birds	Small game	Fish, shell fish and water fowl	Field crops	Threatened species	Natural land vegetation	Aquatic plants	Physiological effects	Psychological effects	Communication effects	Performance effects	Social behavior effects	Life styles	Psychological needs	Physiological systems	Community needs	Regional economic stability	Public sector revenue	Per capita consumption	
OPERATIONS AND MAINTENANCE																																															
Building Repair																																															
Woodworking																																															
Roofing																																															
Concrete & masonry																																															
Electrical systems																																															
HVAC																																															
Road Repairs																																															
Soil and material handling																																															
Resurfacing																																															
Building Demolition																																															
Channel Dredging																																															
Metal Working																																															
Repair of Combat-Associated Materials																																															
Ordnance																																															
Aircraft																																															
Missiles																																															
Ships																																															
Vehicles																																															
Communications equipment																																															
Base Operations O & M (AR37-100-74 Z Accounts)																																															
Aircraft (C1A00)																																															
Automotive equipment (C1B00)																																															
Combat vehicles (C1C00)																																															
Construction equipment (C1D00)																																															
Electronic & communication equipment (C1E00)																																															
Missiles (C1F00)																																															
Ships (C1G00)																																															
Weapons (C1I00)																																															
General equipment (C1K00)																																															
Commodity groups (C1L00)																																															
Plant equipment (C3000)																																															
Radio and T.V. facilities (G2100)																																															
Newspapers (G2200)																																															
Issue commissaries (H4100)																																															
Garrison bread bakeries (H4200)																																															
Dining facilities (H4400)																																															
Central pastry kitchen (H4500)																																															
Commissary stores (H4600)																																															
Laundry and dry cleaning services (H5000)																																															
Hospital and medical facilities (K2500)																																															
Communication services (H1000)																																															
Photographic services (H2100)																																															
Administrative rail services (H3300)																																															
Water service (J1000, K1100, K1130)																																															
Water treatment system (J1200, K1110)																																															
Sewage services (J000, K1200)																																															
Industrial waste treatment facilities (J2300, K1214)																																															
Electrical service (J3000, K1300)																																															
Boiler and heating plants (J4000, K1400)																																															
Cold storage and air conditioning plants (J5000, K1500)																																															
Buildings (K2000)																																															
Grounds maintenance (K3000)																																															
Maintenance other than improved grounds (K3200)																																															
Surfaced areas (K5000)																																															
Marine facilities (See K6000)																																															
Special equipment maintenance (K6000)																																															
Inactive facilities maintenance (K8000)																																															
Fire prevention and protection (M1000)																																															
Refuse handling (M2000)																																															
Pest control services (M3000)																																															
Custodial support (M4000)																																															
Snow removal and ice alleviation (K5000)																																															
Dependents schools (N2100)																																															
Data processing centers (N2300)																																															
Family Housing O&M																																															
Utility operations and maintenance																																															
Refuse collection and disposal																																															
Maintenance of exteriors																																															
Maintenance of interiors																																															
Transportation Services O&M																																															
Material storage																																															
Transfer facilities																																															
Traffic																																															

Figure 3.6. Impact Analysis Work Sheets

IMPACT ANALYSIS WORKSHEET

ACTIVITIES \ ENVIRONMENTAL ATTRIBUTES	AIR									WATER														LAND				ECOLOGY										SOUND			SOCIO ECONOMIC				COMMENTS
																																								HUMAN			ECONOMIC		
	Diffusion factor	Particulates	Sulphur oxides	Hydrocarbons	Nitrogen oxide	Carbon monoxide	Photochemical oxidants	Hazardous variants	Odor	Aquifer safe yield	Flow variations	Oil	Radioactivity	Suspended solids	Thermal pollution	Acid and alkali	Biochemical oxygen demand	Dissolved oxygen (DO)	Dissolved solids	Nutrients	Toxic compounds	Aquatic life	Fecal coliform	Erosion	Natural hazard	Land use patterns	Large animals (wild and domestic)	Predatory birds	Small game	Fish, shell fish and water fowl	Field crops	Threatened species	Natural land vegetation	Aquatic plants	Physiological effects	Psychological effects	Communication effects	Performance effects	Social behavior effects	Life styles	Psychological needs	Physiological systems	Community needs	Regional economic stability	Public sector revenue	Pr. capita consumption	
TRAINING																																												
Support Activities Program																																												
Quartering in Government facilities																																												
Bivouac																																												
Containment																																												
Water supply																																												
Waste disposal																																												
Heating																																												
Quartering in commercial facilities																																												
Feeding personnel at Government facilities																																												
Bivouac																																												
Mess Hall																																												
Feeding personnel at commercial establishments																																												
Movement of personnel and/or equipment																																												
Established routes																																												
Cross country																																												
Commercial carriers																																												
Watercraft																																												
Rotary wing aircraft																																												
Fixed wing aircraft																																												
Amphibious vehicles																																												
Air drops																																												
Assembly area maintenance																																												
Academic Training Program																																												
Mechanical orientation and nomenclature training																																												
Electrical (electronic) orientation nomenclature training																																												
School of the soldier																																												
Administrative and support training																																												
Medical training																																												
Safety orientation and nomenclature training																																												
Security training																																												
Practical Training Program																																												
Weapons training																																												
Small arms																																												
Artillery																																												
Missiles																																												
Explosives																																												
Other weapons																																												
Vehicle operation and maintenance																																												
Technical training (communications, etc.)																																												
Physical training																																												
Tactical training																																												
Escape and evasion																																												
Camouflage																																												
Defense emplacement																																												
Urban warfare																																												
Infiltration course																																												
Assault																																												
Riot control																																												

FIGURE 3.7. IMPACT ANALYSIS WORK SHEETS

IMPACT ANALYSIS WORKSHEET

ACTIVITIES / ENVIRONMENTAL ATTRIBUTES

AIR
- Diffusion factor
- Particulates
- Sulphur oxides
- Hydrocarbons
- Nitrogen oxide
- Carbon monoxide
- Photochemical oxidants
- Hazardous toxicants
- Odor

WATER
- Aquifer safe yield
- Flow variations
- Oil
- Radioactivity
- Suspended solids
- Thermal pollution
- Acid and alkali
- Biochemical oxygen demand
- Dissolved oxygen (DO)
- Dissolved solids
- Nutrients
- Toxic compounds
- Aquatic life
- Fecal coliform

LAND
- Erosion
- Natural hazard
- Land use patterns

ECOLOGY
- Large animals (wild and domestic)
- Predatory birds
- Small game
- Fish, shell fish and water fowl
- Field crops
- Threatened species
- Natural land vegetation
- Aquatic plants

SOUND
- Physiological effects
- Psychological effects
- Communication effects
- Performance effects
- Social behavior effects

SOCIO ECONOMIC

HUMAN
- Life styles
- Psychological needs
- Physiological systems
- Community needs

ECONOMIC
- Regional economic stability
- Public sector revenue
- Per capita consumption

COMMENTS

ACTIVITIES

MISSION CHANGE
- Change in personnel strength
- Change in grade structure or rank
- Alteration of job
- Alteration of job qualifications
- Alteration of physiological constraint (age, sex, health)
- Change in a function or task

REAL ESTATE
- Real Estate Acquisition
  - By purchase, condemnation, or lease
  - By donation or transfer
- Real Estate Dispositions
  - To Governmental agencies
  - To the public
- Outleases of Land
  - For grazing
  - For crops
  - For mineral extraction
- Sale of Timber
  - Overstory removal
  - Sanitation cut
  - Thinning
  - Clear cutting
  - Reforestation

PROCUREMENT
- Principal Items
  - Aircraft
    - Fixed wing
    - Rotary wing
  - Weapons
    - Crew-served
    - Individual
    - Artillery
    - Tracked combat vehicles
  - Missiles
  - Ammunition
  - Other procurement
- Secondary Items
  - Procurement, army secondary items
  - Stock fund items
    - From other Government agencies (GSA, etc.)
    - Local procurement
- Procurement of Utilities and Services from Civilian Sector
  - Utilities
  - Services
- Non-Appropriated Fund Activities
  - Personnel support
    - Food oriented
    - Non-food oriented
  - Post exchanges

Figure 3.8. Impact Analysis Work Sheets

IMPACT ANALYSIS WORKSHEET

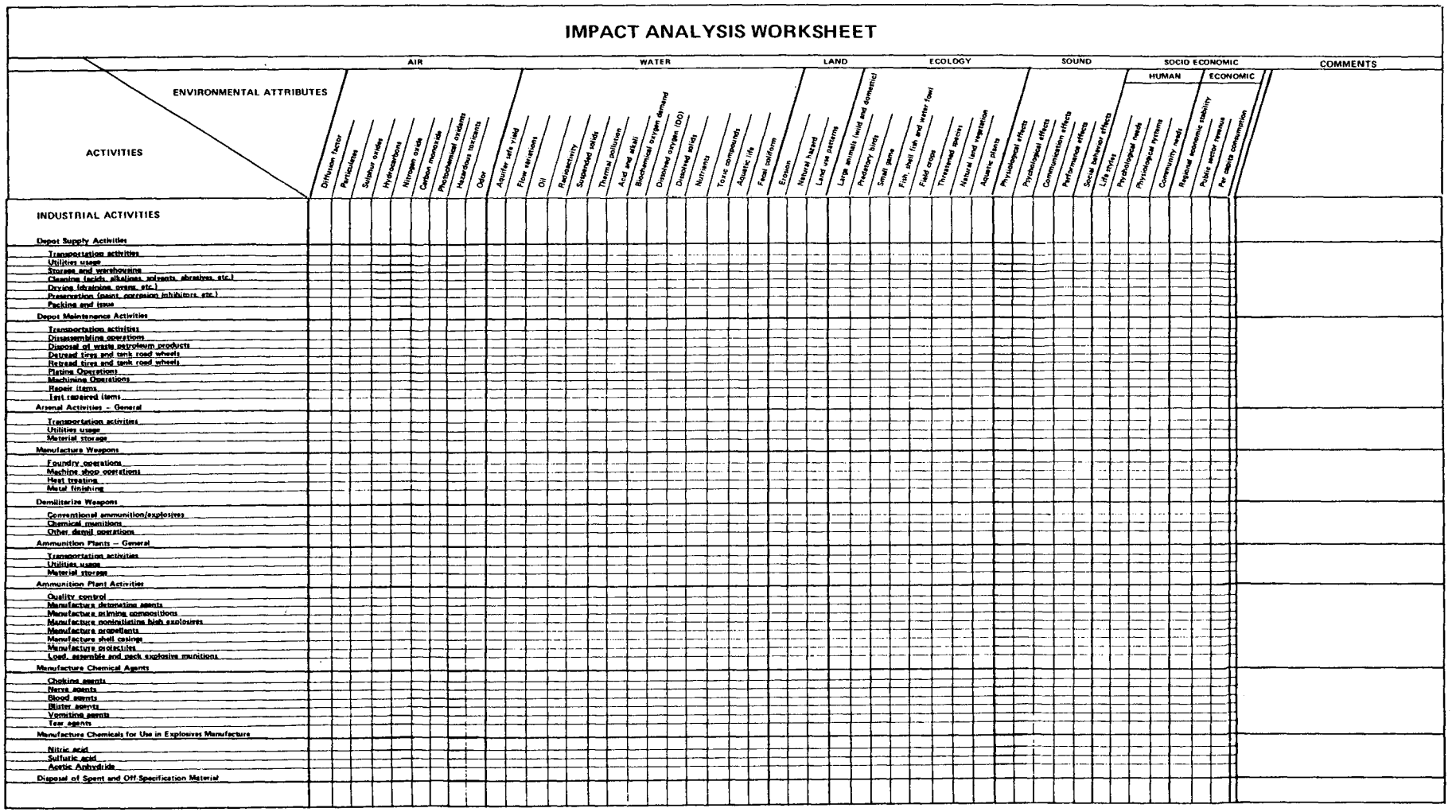

FIGURE 3.9. IMPACT ANALYSIS WORK SHEETS

IMPACT ANALYSIS WORKSHEET

ACTIVITIES \ ENVIRONMENTAL ATTRIBUTES	AIR										WATER																		LAND				ECOLOGY										SOUND				SOCIO ECONOMIC					
																																														HUMAN				ECONOMIC		
	Diffusion factor	Particulates	Sulphur oxides	Hydrocarbons	Nitrogen oxide	Carbon monoxide	Photochemical oxidants	Hazardous toxicants	Odor	Aquifer safe yield	Flow variations	Oil	Radioactivity	Suspended solids	Thermal pollution	Acid and alkali	Biochemical oxygen demand	Dissolved oxygen (DO)	Dissolved solids	Nutrients	Toxic compounds	Aquatic life	Fecal coliform	Erosion	Natural hazard	Land use patterns	Large animals (wild and domestic)	Predatory birds	Small game	Fish, shell fish and water fowl	Field crops	Threatened species	Natural land vegetation	Aquatic plants	Physiological effects	Psychological effects	Communication effects	Performance effects	Social behavior effects	Life styles	Psychological needs	Physiological systems	Community needs	Regional economic stability	Public sector revenue	Per capita consumption	
RESEARCH, DEVELOPMENT, TEST AND EVALUATION (RDTE)																																																	
Chemical and Biological Research																																																	
Basic laboratory research																																																	
Material disposal																																																	
Waste disposal																																																	
Laundry																																																	
Semiworks -- pilot plant development																																																	
Operate semiworks																																																	
Waste disposal																																																	
Proving ground																																																	
Agent disposal																																																	
Waste disposal																																																	
Site contamination																																																	
Testing Programs																																																	
Abrasion tests																																																	
Acceleration tests																																																	
Chemical tests																																																	
Core tests																																																	
Corrosion tests																																																	
Crash tests																																																	
Cross-country tests																																																	
Destructive tests																																																	
Firing tests (ordnance)																																																	
Flight tests																																																	
Full scale tests																																																	
Impact tests																																																	
Mechanical tests																																																	
Missile tests																																																	
Nondestructive tests																																																	
Performance tests																																																	
Physiological tests																																																	
Propellant tests																																																	
Psychological tests																																																	
Radiation tests																																																	
Shock tests																																																	
Soil tests																																																	
Static tests																																																	
Ultrasonic tests																																																	
Vibration tests																																																	
X-Ray inspection																																																	
ADMINISTRATION AND SUPPORT																																																	
Executive Office Actions																																																	
Issuance of orders and guidance																																																	
Personnel actions																																																	
Public communications																																																	
Personnel Services																																																	
Information Manipulation																																																		
Services																																																	
Legal																																																	
Library																																																	
Mail																																																	
Veterinarian																																																	

FIGURE 3.10. IMPACT ANALYSIS WORK SHEETS

APPENDIX A

ATTRIBUTE DESCRIPTOR PACKAGE

AIR

Air-quality attributes are factors that indicate the quality of the air. Basically, two kinds of environmental factors relate to air quality. They relate to:

- Structure and elements of the environment
- Inputs to or emissions from human activities.

Factors relating to the structures and elements of the air environment are stability, temperature, mixing depth, wind speed, wind direction, humidity, precipitation, pressure, and topography. On the other hand, factors relating to inputs from human activity are dust, fumes, fly ash, smoke, soot, and compounds of arsenic, aluminum, etc.

Under the ongoing comprehensive Environmental Impact Study titled "Procedures for Evaluating Environmental Impacts of Army Military Programs", CERL has developed 95 attributes for Air Quality.[1] For this study, it was decided to aggregate some of these attributes to develop a list of critical attributes to be used for environmental impact assessment. As a result, a set of attributes was chosen.

The attributes that summarize all 95 of CERL attributes are:

Diffusion factor
Particulates
Sulfur oxides
Hydrocarbons
Nitrogen oxides
Carbon monoxide
Photochemical oxidants
Hazardous toxicants
Odors.

The first attribute, the diffusion factor, is related to the structure and elements of the environment, the remaining attributes are related to the emissions from human activities.

DIFFUSION FACTOR

Definition of the Attribute

Diffusion factor is an attribute that is related to various atmospheric and topographic attributes of the environment. For example, vertical temperature structure affects movement of air in the atmosphere. Wind structure in a region determines the scavenging action in the environment as well as the impact of inversions. Topography may change temperature and wind profiles because of the combined effects of surface friction, radiation, and drainage. Valleys are more susceptible to stagnation and to air pollution than are flat lands or hill slopes. The mixing depth, in fact, also determines the intensity of air pollution in a given region. The status of stability or instability of the atmosphere determines to what extent air pollution can build up in a given region. Humidity and pressure also affect the diffusion rate of a given pollutant emitted to the atmosphere. In addition, precipitation is an important scavenger element that can clean up pollutants in the air.

All of the above environmental factors together determine the diffusion factor in a given region.

Army Activities That Affect the Attribute

Generally, most Army activities will not affect the diffusion factor. However, should future research show the possibility of certain Army activities affecting the weather and other related meteorological factors, it will be necessary to consider such Army activities that are now known (about which few details are available) which may impact the diffusion factor. For instance, should the Army develop artificial methods for generating storms and seeding clouds, research and testing of these new and powerful methods can and will cause changes in the diffusion factor.

Source of Effects

As indicated above, impacts of certain specialized Army activities can have a major effect on the diffusion factor. However, details of these activities are generally classified information; hence, it is not

possible to provide detailed information on their potential impacts.

Variables to be Measured

Variables to be measured to determine the diffusion factor are many. The major ones are stability, mixing depth, wind speed, precipitation, and topography. Various measures of each of these variables will indicate the extent and nature of the diffusion factor in a given region.

How Variables are Measured

Generally, data on stability, mixing depth, wind speed, direction, and precipitation are collected by meteorological survey stations of the U.S. Weather Bureau. Data on these attributes are readily available from the Bureau offices across the country. Topography data can be obtained from the United States Geological Survey (USGS) maps of largest available scale.

Data Sources. Primary sources of data for the variables that define diffusion factors are the U.S. Weather Bureau and the USGS; both have offices in most major cities throughout the country.

Skills Required. Collection and analysis of such data require a sophisticated meteorological background. Persons with a Masters Degree in Meteorology and trained technicians are required to collect and develop information relating to these variables.

Instruments. A full-scale meteorological laboratory is needed to monitor the selected attributes that define the nature and extent of the air diffusion factor.

Evaluation and Interpretation of Data

The diffusion factor can be classified into three or more major ratings. For example, the diffusion factor can be High, Medium, or Low. The High rating represents an environmental quality (EQ) value of 1.0; the Medium rating represents an EQ value of 0.5; and the Low rating represents an EQ value of 0.

The environmental impact of selected activities on diffusion factor is measured by the change in diffusion factor ratings. When a diffusion factor changes only a small amount and its rating remains unaltered, the impact is considered Insignificant. When the change in the diffusion factor rating is altered by one step (e.g., between High and Medium or Medium and Poor) the impact is considered to be Moderate. When a change in the diffusion factor rating occurs through two steps (e.g., between High and Poor) the impact is treated as Significant.

Special Conditions – (None)

Geographical and Temporal Limitations

There can be substantial variation in the diffusion factor spatially and temporally, depending upon variations in the determinant variables. It is known, for instance, that wind speed, precipitation, stability, and mixing depth change with time and location in a given region. These variations, therefore, alter the diffusion factor accordingly.

Mitigation of Impact

Generally, the impact of most Army activities on diffusion has not been adequately defined. The mitigation techniques are also not well established.

Other Comments

Research is needed to identify potential Army activities, their impacts, and the mitigation strategies relating to potential impacts on the diffusion factor. Also, a mathematical model is needed to relate all of the determinant variables to the diffusion factor. This will help establish a suitable relationship between variables and the diffusion factor.

Additional References

Stern, A., "Air Pollution", Volume I, Academic Press, New York, 1962, pp 80-117.

PARTICULATES

Definition of the Attribute

Particulates are the most prevalent air pollutant. They exist in the form of minute separate particles suspended in the air.

Particulates are finely divided solid and liquid particles suspended in the ambient air. They range from over 100 microns to less than 0.01 microns in diameter. Particulates of smaller size (less than 10 microns) suspended in air can scatter light and behave like a gas. These smaller particulates are called aerosols.

Army Activities That Affect the Attribute

Many Army activities generate particulates that are emitted to the air. These include construction, operation, maintenance, and repair activities; real estate activities; and industrial activities. Examples of subactivities are preparation, demolition, removal, and disposal; excavation; concrete construction; operation and maintenance of aircraft; operation and maintenance of automotive equipment; use of construction equipment; use of explosives; mineral extraction; foundry operations; manufacturing; noninitiating high explosives.

Sources of Effects

In general, the environment contains a certain level of particulate matter. Emissions resulting from various construction activities are released to the environment causing a higher concentration of particulates. Particulates can cause increased mortality and morbidity in the exposed population by aggravating diseases such as bronchitis, emphysema, and cardiovascular diseases. Particulates soil clothes and buildings and can cause serious visibility problems. Steel and other metal structures can be corroded as a result of exposure to particulates and humidity. Property values and psychic welfare of people can be undermined.

Variables to be Measured

Particulate concentration is generally measured as the concentration of all solid and liquid particles averaged over a period of 24 hours. For purposes of impact assessment, particulate concentration is measured as the average annual arithmetic mean of all 24-hour particulate concentrations at a given location.

How Variables are Measured

Particulate concentrations are usually measured by a High Volume Method, as specified in the *Federal Register* of April 30, 1971.[2] The air is drawn into a covered housing, through a filter by a high-flow blower at a rate of 40-60 cubic feet per minute. The particles, ranging from 100 to 0.1 microns in diameter, are ordinarily collected on fiberglass filters. The concentration of suspended particulates is then computed by measuring the mass of collected particulates in the volume sample in micrograms per cubic meter.

Data Source. Sources of data are generally state pollution-control departments, county air-pollution-control offices, multicounty air-pollution-control offices, or city air-pollution-control offices. The Army can also install High Volume Samplers to monitor particulates from its operation.

Skills Required. Basic paraprofessional training in mechanical or chemical engineering with special training in operating high volume samplers is adequate to collect particulate concentration data. Specialized supervision is needed to ensure that data are properly collected and analyzed.

Instruments. The apparatus used for sampling particulate concentration is called a High Volume Air Sampler. The sampler is installed in a shelter to protect it against extremes of temperature, humidity, and other weather conditions. It has a filter medium with a collection efficiency of about 99 percent for particles of 0.3 microns in diameter.

Evaluation and Interpretation of Data

The primary effects of particulates on environmental quality range from visibility problems to health impairments. Visibility problems occur at concentrations as low as 25 $\mu g/m^3$. As the concentration of particulates increases to about 200 $\mu g/m^3$ human health begins to be affected. The concentration levels mentioned above refer to 24-hour average annual concentration. Particulate concentration of less than 25 $\mu g/m^3$ is also considered less desirable for the

environment, since it provides condensation nuclei upon which fog and cloud droplets settle. Based on these considerations, a particulate value function was developed based on a 24-hour average annual concentration, as shown in Figure A-1.

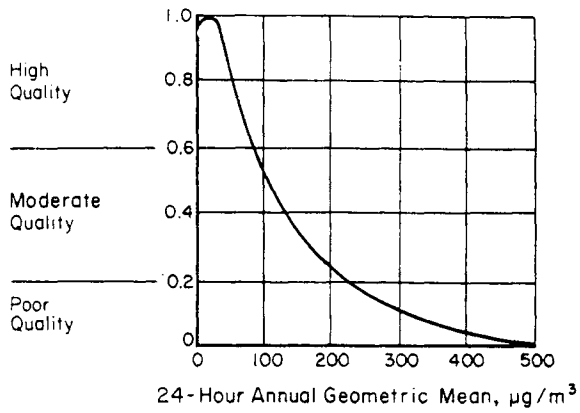

Figure A-1. Particulate Value Function

The determination of environmental impact of proposed activities on particulate level is measured by the change in particulates concentration. When the particulates concentration changes to the extent that its rating remains unaltered (e.g., High Quality air remains High Quality), the impact is considered Insignificant. When the change in particulates concentration is such that its rating changes by one step (e.g., between High Quality and Moderate Quality), the impact is treated as Moderate. When a change in particulates rating occurs through two steps (e.g., between High Quality to Low Quality, and vice versa), the impact is treated as Significant.

The particulate value function (Figure A-1) is used for rating air quality in terms of High, Moderate, and Low Quality based on 24-hour annual geometric mean. For a given value of 24-hour annual geometric mean particulates concentration on the horizontal axis, a point on the curve identifies the environmental quality rating from the vertical axis of Figure A-1 (e.g., 130 $\mu g/m^3$ indicates a moderate quality of 0.4).

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of particulates does not remain constant over the entire spatial extent of a given region. Also, it will not remain constant over time. As such, substantial spatial and temporal variations in the concentration of particulates can be expected. It is generally claimed that the impact of particulates on the environment and on man depends on the total amount of exposure over the entire year. Spatial variations can be accounted for by analyzing miniscule units of urbanized regions. This requires extensive calculations based on a diffusion model or a large-scale monitorial program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial area.

Mitigation of Impact

Particulate pollution impacts can be mitigated by means of three major alternatives:

- Reduction in particulate emission from sources.
- Reduction or removal of receptors from the polluted areas.
- Uses of protected controlled environment (e.g., oxygen masks, Houston Astrodome).

A combination of the above three alternatives should be considered to provide an optimal strategy for the mitigation of particulate pollution impacts.

Other Comments

Particulates are present even in the cleanest air at the most remote locations uncontaminated by man. Sources of particulate pollution relate to activities such as construction, industrial operations, and operation/maintenance/repair work at military bases. Automobile emissions are only a minor source of particulate pollution.

Additional References

"Guidelines for Development of a Quality Assurance Program. Reference Method for the Determination of Suspended Particulates in the Atmosphere (High Volume Method)", Environmental Protection Agency, August 1973.

SULFUR OXIDES

Definition of the Attribute

Sulfur oxides are common air pollutants, generated primarily by combustion of fuel. Solid and liquid fossil fuels contain a high degree of sulfur in the form of inorganic sulfides and organic sulfur compounds. Combustion of fossil fuels normally produces about 30 parts sulfur dioxide and 1 part sulfur trioxide.

Sulfur oxides are usually a combination of sulfur dioxide, sulfur trioxide, sulfuric acid, and sulfurous acid. Sulfur dioxide is the most dominant portion of the sulfur oxides concentration; as such, the sulfur oxides attribute is defined in terms of sulfur dioxide parameter.

Sulfur dioxide is a nonflammable, nonexplosive, transparent gas with a pungent, irritating odor. The concentration of this gas in parts per million (ppm) measures the magnitude of sulfur oxides pollution in a given region.

Army Activities That Affect the Attribute

Several activities at an Army base use fossil fuels. Industrial operations, research/development testing/evaluation operations, and training operations appear to be major generators of sulfur dioxide pollution at any Army base. In addition, operation of various facilities can cause significant sulfur dioxide pollution. Construction work at the bases also creates a minor sulfur dioxide problem from the operation of diesel engines.

Source of Effects

The effect of sulfur dioxide pollution can be higher morbidity, increased mortality, increased incidence of bronchitis, respiratory diseases, emphysema, and general deterioration of health. It can also cause increased corrosion of metals, chronic plant injury, excessive leaf dropping, and reduced productivity of plants and trees. The effect of sulfur dioxide pollution in the presence of particulates can result in synergistic impacts on the environment. Synergistic impacts of sulfur dioxide in the presence of nitrogen dioxide have also been noted. For example, a concentration of 0.04 ppm sulfur dioxide alone does not affect bronchitis or lung-cancer patients. However, this concentration of sulfur dioxide combined with 160 $\mu g/m^3$ particulates caused an appreciable increase in the mortality of bronchitis and lung-cancer patients.[3]

Variables to be Measured

The primary variable that measures the extent of the sulfur oxides problem is expressed by the 24-hour annual arithmetic mean concentration of sulfur dioxide present in the ambient air. The variable is used to predict potential sulfur oxides impact on the environment.

Here, the use of one variable is not entirely adequate. Concentration of particulates, ozone, and nitrogen oxides affects the impacts of sulfur oxides. However, to take advantage of the simplification, only one variable has been used.

How Variables are Measured

The sulfur dioxide concentration is commonly measured by the Pararosaniline method.[2] In principle, sulfur dioxide is absorbed from air in a solution of potassium tetrachloromercurate (TCM). The resulting complex is added to pararosaniline and formaldehyde to form an intensely colored acid solution which is analyzed spectrophotometrically. The spectrophotometric analysis is a colorimetric method in which the concentration of sulfur dioxide absorption is measured by the intensity of the color produced in the resulting acid solution. The method is recommended by the Environmental Protection Agency in the National Primary and Secondary Ambient Air Quality Standards published in the *Federal Register* of April 30, 1971.[2]

Data Source. Air-quality measurements on sulfur oxide are made by air-quality monitoring programs established by state pollution-control agencies, the Federal Environmental Protection Agency and county, regional, multicounty, or city air-pollution-control agencies. Generally, the data are compiled annually and are published with summaries by the state agency for air-quality monitoring.

Skills Required. The skills required for measuring sulfur dioxide concentration in air can be developed by special technician-level training imparted at a technical school or as part of an on-the-job

training program. Technician-level training in mechanical and chemical engineering is adequate to develop the necessary skills to operate a monitoring and recording system for sulfur dioxide.

Instruments. The instruments required for monitoring sulfur dioxide concentration are

All-glass midget impinger
Air pump
Air flowmeter
Spectrophotometer.

Evaluation and Interpretation of Data

A review of literature indicates that the minimum sulfur dioxide concentration for vegetation damage is 0.03 ppm. A sulfur dioxide concentration less than 0.03 ppm should be considered a characteristic of a safe environment. As concentration increases, more damage will be done to the vegetation and materials. Visibility of the atmosphere is also impaired. At a concentration of 0.2 ppm of sulfur dioxide, increased mortality rates are observed. This situation should reflect a value function of zero. Based on these considerations, a value function was developed for sulfur oxide as shown in Figure A-2.

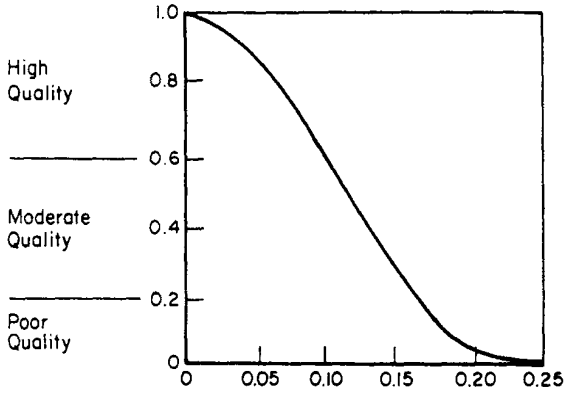

Figure A-2. Sulfur Dioxide Value Function

The determination of environmental impact of proposed activities on sulfur dioxide level is measured by the change in sulfur dioxide concentration. When the sulfur dioxide concentration changes to the extent that its rating remains unaltered (i.e., High Quality air remains High Quality, and so on), the impact is considered Insignificant. If the change in sulfur dioxide concentration is such that its rating changes by one step (i.e., from High Quality to Moderate Quality, etc.), the impact is treated as Moderate. Furthermore, when a change in sulfur dioxide rating occurs through two steps (i.e., from High Quality to Low Quality, and vice versa), the impact is treated as Significant.

The sulfur dioxide value function (Figure A-2) is used for rating air quality in terms of High, Moderate, and Low Quality based on 24-hour annual arithmetic mean. For a given value of 24-hour annual geometric mean sulfur dioxide concentration on the horizontal axis, the environmental quality rating can be read for the horizontal axis in Figure A-2.

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of sulfur dioxide does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over time. As such, substantial spatial and temporal variations in the concentration of sulfur dioxide on the environment and on man depends on the total amount of exposure over the entire year. Spatial variations can be accounted for by taking miniscule units of urbanized regions for purposes of analysis. This requires extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial region.

Mitigation of Impact

The impacts can be mitigated by means of three major alternatives or a combination thereof:

- Reduction in sulfur dioxide emissions from sources
- Reduction or removal of receptors from the polluted areas
- Uses of protected, controlled environment, such as oxygen masks, Houston Astrodome, etc.

Other Comments

Sulfur dioxide is generally harmful to the health and welfare of a community. Its impact can be substantially increased by the presence of suspended particulates due to the synergistic relationship of the two pollutants. Despite this, the value function is based only on the concentration of sulfur dioxide. This is done to simplify the value function. However, the impacts have been adjusted for the concentration of particulates that generally accompany given levels of sulfur dioxide in the ambient air.

Additional References

"Guidelines for Development of a Quality Assurance Program. Reference Method for Measurement of Sulfur Dioxide", Environmental Protection Agency, August 1973.

HYDROCARBONS

Definition of the Attribute

Hydrocarbon is a general term used for several organic compounds emitted when petroleum fuels are burned. Automobile exhaust accounts for over half of the complex mixture of hydrocarbons emitted to the atmosphere; the remaining hydrocarbons arise from natural sources like decomposable organic matter on land, swamps, and marshes; hydrocarbon haze from plants and forest vegetation; geothermal areas; coal fields, natural gas, and petroleum fields; and forest fires. Usually, hydrocarbons consist of methane, ethane, propane, and other derivatives of aliphatic and aromatic organic compounds.

The hydrocarbons attribute is defined as the total hydrocarbon concentration (THC) present in the ambient air. Hydrocarbons are organic compounds consisting of carbon and hydrogen; their concentration is measured in parts per million by volume or in micrograms per cubic meter of air. For most U.S. cities, except Los Angeles, the peak hydrocarbon concentration occurs between 6:00 and 9:00 a.m.

Army Activities That Affect the Attribute

Many Army activities emit high levels of hydrocarbons into the environment. For example, industrial operations involve substantial combustion of fuel causing hydrocarbon emissions due to inefficient combustion processes. Gasoline and diesel engines are used by the Army for purposes of construction, operation, maintenance, repair, and training. In addition, many Army industrial activities have petroleum and petrochemical operations that emit high levels of hydrocarbons. The Army bases are also surrounded by different kinds of natural vegetation and forests. These natural areas also generate high levels of hydrocarbon concentration.

Source of Effects

Hydrocarbons are of concern primarily for their role in the formation of photochemical oxidants and smog. Direct health effects of gaseous hydrocarbons in the ambient air have not been demonstrated. Health effects occur only at high concentrations (about 1000 ppm or more) that interfere with oxygen intake, Hydrocarbons in the atmosphere have been

found to cause lacrimation, coughing, sneezing, headaches, nervous weakness, laryngitis, pharyngitis, and bronchitis even at low concentrations. In addition, hydrocarbons may cause breathing problems and eye irritation. In combination with nitrogen oxides, hydrocarbon impacts can be significantly increased.

Variables to be Measured

The variable expressing the impact of hydrocarbons is measured by the 3-hour average annual concentration of ambient hydrocarbons, expressed in parts per million. The time concentration is measured from 6:00 to 9:00 a.m. at which time peak hydrocarbon concentration is expected to occur in most U.S. cities except Los Angeles.

Nitrogen oxide variables interact synergistically with the concentration of hydrocarbons. Nitrogen oxides combined with hydrocarbons generate oxidants causing smog. The impact of smog is significantly greater than that of hydrocarbons alone. However, for purposes of simplicity, nitrogen oxides are treated as a separate variable.

How Variables are Measured

There are two different methods of analysis for the total hydrocarbons

Flame ionization method[2]
Spectrophotometric method.[4]

The Environmental Protection Agency in its national primary and secondary ambient-air-quality standards document has recommended use of the hydrogen-flame ionization method to measure total hydrocarbon concentration. The flame ionization technique (FID) uses a measured volume of ambient air delivered semicontinuously (about 4 to 12 times per hour) to a hydrogen-flame ionization detector. A sensitive electrometer detects the increase in ion concentration which results from the interaction of hydrogen flame with a sample of air contaminated with organic compounds such as hydrocarbons, aldehydes, and alcohols. The ion-concentration response is approximately proportional to the number of organic carbon atoms in the sample. The FID serves as a carbon-atom counter.

The measurement can be made by two modes of operation:

- A complete chromatographic analysis showing continuous output from the detector
- Programming the system to display selected output from the detector.

The latter is adequate for recording hydrocarbons system concentration values from 6:00 to 9:00 a.m. only.

Data Sources. Hydrocarbon data are generally collected by state air-quality-monitoring programs. Other potential sources include the Federal Environmental Protection Agency, and city or county monitoring agencies.

Skills Required. Basic paraprofessional training in mechanical or chemical engineering with special training in operating air-pollution samplers is adequate to collect data relating to hydrocarbons. Specialized supervision is needed to insure that the instruments are correctly operated and recorded. This requires either experienced personnel or experienced consultants specialized in air-quality monitoring.

Instruments. Instruments used for measuring hydrocarbons are the following:

- Commercial Total Hydrocarbon Concentration (THC) analyzer
- Sample-introduction system (including pump, flow control valves, automatic switching valves, and flow meter)
- In-line filter (a binder-free glass-fiber filter with a porosity of 3 to 5 microns)
- Stripper or percolumn (the column should be repacked or replaced every 2 months of continuous use)
- Oven (containing analytical column and analytic converter).

The instruments are installed and connected in accordance with the manufacturers' specifications.

Evaluation and Interpretation of Data

The extent of hydrocarbon impact is measured by the degree to which it affects smog intensity. Hydrocarbon criteria are, therefore, keyed to the 6:00 to 9:00 a.m. average annual concentration. At low concentrations, hydrocarbons are relatively harmless and unimportant. The quality of the environment

deteriorates rapidly as conditions for smog development approach (i.e., 0.15 ppm to 0.25 ppm). A sharp decrease in environmental quality is noted within this range. Above 0.25 ppm hydrocarbon concentration, the value function gradually levels off to zero, since the marginal impact of increases in hydrocarbons concentration is small. The value function is thus a flat "S" curve. On the basis of these considerations, the hydrocarbons value function shown in Figure A-3 was developed.

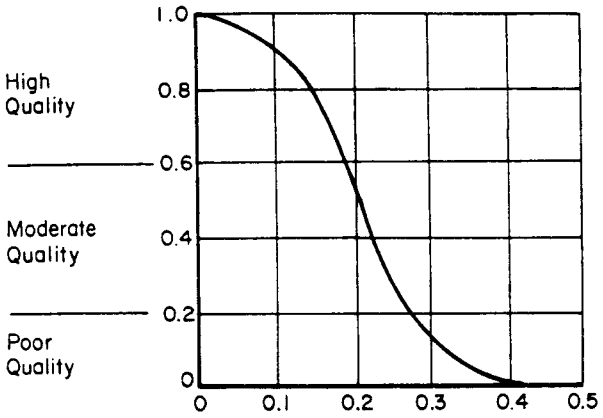

Figure A-3. Hydrocarbons Value Function 3-Hour Average Annual Concentration (0600-0900), ppm

The determination of environmental impact of proposed activities on hydrocarbons level is measured by the change in hydrocarbon concentration. When the hydrocarbon concentration changes to the extent that its rating remains unaltered (e.g., High Quality air remains High Quality), the impact is considered Insignificant. When the change in hydrocarbons concentration is such that its rating changes by one step (e.g., between High Quality and Moderate Quality), the impact is treated as Moderate. When a change in hydrocarbons rating occurs through two steps (e.g., from High Quality to Low Quality, and vice versa), the impact is considered Significant.

The hydrocarbons value function (Figure A-3) is used for rating air quality in terms of High, Moderate, and Low Quality based on 3-hour average annual concentration. For a given value of 3-hour average annual concentration on the horizontal axis, a point on the curve identifies the environmental quality rating from the vertical axis of Figure A-3 (e.g., 0.3 ppm indicates a Poor Quality of 0.15).

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of hydrocarbons does not remain spatially constant in a given region. Also, it will not remain constant over time. As such, a substantial spatial and temporal variation in the concentration of hydrocarbons can be expected. It is generally claimed that the impact of hydrocarbons on the environment and man depends on the total amount of exposure during peak periods. Spatial variations can be accounted for by taking small units of urbanized regions for analysis. This requires extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial area.

Mitigation of Impact

There are four major strategies for the mitigation of impacts of hydrocarbons on the environment. These are

- Control of motor-vehicle emissions
- Control of stationary-source emissions (including evaporation, incineration, absorption, condensation, and material substitution)
- Reduction or removal of receptors from polluted areas
- Creation of controlled environment to avoid pollution (including use of oxygen masks).

These strategies can be used in an optimal combination in order to get the best results from an abatement program.

Other Comments

Hydrocarbon concentration is one of the parameters that defines the extent of smog development in an environment. In selecting attributes the ozone parameter was avoided since the formation of ozone

is determined by the interaction of hydrocarbons and nitrogen oxides in the presence of sunlight. The environment receives many different kinds of hydrocarbon emissions; as such it is an important indicator of environmental impact.

Additional References

NITROGEN OXIDES

Definition of the Attribute

Many nitrogen oxides are found in the urban environment. The most important are nitric oxide (NO) and nitrogen dioxide (NO_2). In addition, nitrous oxide (N_2O) is another oxide of nitrogen present in the atmosphere in appreciable concentration. The term NO_x is often used to represent the composite atmospheric concentration of nitrogen oxides in the environment.

Nitrogen oxides are emitted by exhausts from high-temperature combustion sources. They result from the reaction of nitrogen with oxygen; with hydrocarbons they produce photochemical smog. Nitrogen oxide concentrations are measured in parts per million by volume.

Army Activities That Affect the Attribute

Many Army activities generate nitrogen oxides which are emitted to the air. Industrial operations, research/development/testing operations, operation and maintenance of motor vehicles and stationary combustion sources (like power plants, natural-gas burners, diesel-operated construction machineries) are some of the sources of nitrogen oxides at an Army base. However, a large portion of nitrogen oxides is produced by natural sources such as bacterial action in forests, swamps, and parks.

Source of Effects

There is very little documented information on the health effects of nitrogen oxides at concentrations normally found in ambient air. The human threshold for sensing the odor of nitrogen dioxide is about 0.12 ppm. Data from human and animal studies indicate that nitrogen oxides have untoward effects on human health. Nitrogen dioxide is about four times more toxic than nitric oxide.[5]

In addition, nitrogen oxides can affect vegetation, causing acute (chronic) injury to leaves as well as to productivity of certain plants. Nickel alloys are subject to corrosion in the presence of nitrogen oxides; synthetic fibers fade, and white clothes yellow in the presence of nitrogen oxides.

Variables to be Measured

The variable measuring the extent of nitrogen oxides pollution is the average annual concentration of nitrogen oxides in the ambient air. The nitrogen oxides level is measured in parts per million (ppm).

Other variable factors that might interact with nitrogen oxides are hydrocarbons and particulates. These variables are considered separately in defining air-quality impacts, even though they interact synergistically.

How Variables are Measured

Nitrogen dioxide is the only atmospheric nitrogen oxide which can be measured directly with current techniques.* Measurement of nitrogen oxides, therefore, must rely on some type of converter that oxidizes nitric oxide to nitrogen dioxide.

The reference method for the determination of nitrogen dioxide is the Griess-Saltzman technique, modified by the Environmental Protection Agency. It is a 24-hour continuous-sampling method. In principle, nitrogen dioxide contaminated air is bubbled through a sodium hydroxide solution which forms a stable solution of sodium nitrite. The nitrite concentration in the sample solution is measured colorimetrically by the reaction of an exposed absorbing agent with phosporic acid, sulfanilamide, and NEDA solution.

Data Sources. Sources of data are generally state pollution-control departments and county, multicounty, or city air-pollution-control offices. The Army can also install monitoring samplers at critical distances from its operation to determine the level of nitrogen oxides generated by its activities.

Skills Required. Basic paraprofessional training in mechanical or chemical engineering with special training in operating air-quality sampling devices is adequate to collect data relating to nitrogen oxides. Specialized supervision is needed to insure that the data are properly collected and analyzed. Specialized supervision should include personnel or experienced consultants trained in the field of air-quality monitoring.

Instruments. Nitrogen dioxide is measured with an apparatus consisting of the following instruments:

- Absorber tubes
- Probe with membrane filter, glass funnel, and trap
- Flow-control device with a calibrated 27-gauge hypodermic needle and a membrane filter protection
- Air pump capable of maintaining a flow of 0.2 liters per minute and a vacuum of 0.7 atmosphere
- Calibration equipment.

Evaluation and Interpretation of Data

Generally, nitrogen oxide concentration below 0.05 ppm (on average annual basis) does not pose a health problem. Exposure above this level can be correlated with a higher incidence of acute respiratory problems. At levels higher than those normally present in ambient air (i.e., about 0.05 ppm), nitrogen dioxide acts as a toxic agent. Based on these considerations, a nitrogen dioxide value function has been developed as shown in Figure A-4.

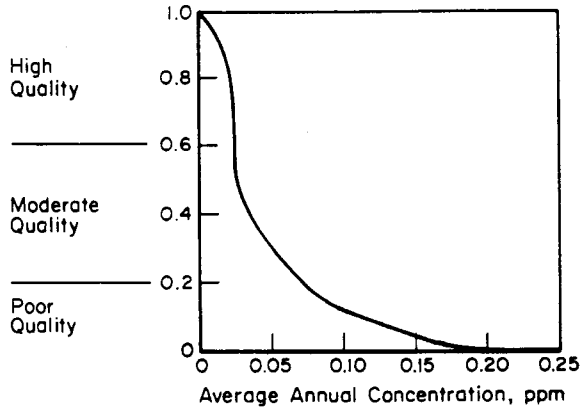

Figure A-4. Nitrogen Oxides Value Function

*The extent of nitrogen oxides pollution is measured by the concentration of nitrogen dioxide expressed in terms of annual arithmetic mean concentration.

The determination of environmental impact of proposed activities on nitrogen oxides level is measured by the change in nitrogen oxides (NO_x) concentration. When the NO_x concentration changes to the extent that its rating remains unaltered (e.g., High Quality air remains High Quality), the impact is considered Insignificant. When the change in NO_x concentration is such that its rating changes by one step (e.g., between High Quality and Moderate Quality), the impact is treated as Moderate. When a change in NO_x ratings occurs through two steps (e.g., from High Quality to Low Quality, and vice versa), the impact is considered Significant.

The nitrogen oxides value function (Figure A-4) is used for rating air quality in terms of High, Moderate, and Low Quality based on average annual concentration. For a given value of average annual concentration on the horizontal axis, a point on the curve identifies the environmental quality rating from the vertical axis of Figure A-4 (e.g., 0.1 ppm indicates a Poor Quality of 0.1).

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of nitrogen dioxide does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over time. As such, substantial spatial and temporal variations in the concentration of nitrogen dioxide can be expected. It is generally claimed that the impact of nitrogen dioxide on the environment and man depends on the total amount of exposure over the entire year. Spatial variations can be accounted for by analyzing small units of urbanized regions. This requires extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial area.

Mitigation of Impact

There are four major strategies for the mitigation of impacts of nitrogen dioxide on the environment. These are

- Control of motor-vehicle emissions
- Control of stationary-source emissions (including incineration and evaporation)
- Reduction or removal of receptors from polluted areas
- Creation of controlled environment to avoid pollution (such as the use of oxygen masks).

These strategies can be used in optimal combination to get the best results from an abatement program.

Other Comments

The standards for nitrogen dioxide are currently being examined by the Environmental Protection Agency and the value function for nitrogen dioxide could change as a result.

Additional References

CARBON MONOXIDE

Definition of the Attribute

Carbon monoxide (CO) is the most widely distributed and most commonly occurring air pollutant. The majority of atmospheric CO is produced by the incomplete combustion of carbonaceous materials used for fuels for vehicles, space heating, industrial processing, and the burning of refuse.

Army Activities That Affect the Attribute

All Army activities that involve the combustion of organic materials are sources of CO. In addition, industrial operations of the Army also contribute to the CO burden of the air. CO is also formed by explosions, firing of weapons, and can occur naturally.

Source of Effects

Adverse health effects on humans have been observed for exposures of 8 hours or more at CO concentrations of 12 to 17 milligrams per cubic meter (10 to 15 ppm). Adverse health effects consist of impaired time interval discrimination, physiologic stress on heart patients, etc.

There is however no evidence that CO has adverse effects on vegetation or materials.

Variables to be Measured

The concentration of CO is measured in micrograms per cubic meter. The variable measuring the extent of carbon monoxide pollution is the maximum 8-hour concentration of CO that has been recorded over a period of 1 year.

How Variables are Measured

The reference method for the continuous measurement of carbon monoxide is nondispersive infrared spectrometry. The measurement technique is based on the absorption of infrared radiation by carbon monoxide. By comparing absorption of infrared radiation passing through a reference cell and a test cell electronically, the concentration of CO in the test cell can be measured.

Instruments are available that measure in the range of 0 to 58 mg/m^3. The sensitivity is 1 percent of full scale response per 0.6 mg CO/m^3 (0.5 ppm).

Data Sources. The sources of data are generally the State Pollution Control Department, the County Air Pollution Control Office, or the City Air Pollution Control Office. The Army can also install monitoring equipment at critical locations near its operations to determine the level of carbon monoxide generated by its activities.

Skills Required. A basic paraprofessional training in mechanical or chemical engineering with special training in operating the air-quality instruments is adequate to collect data relating to carbon monoxide. Specialized supervision will be needed to insure that the data are properly collected and analyzed. Specialized supervision should include trained and experienced personnel or experienced consultants in the field of air-quality monitoring.

Instruments. Instruments recommended for measuring carbon monoxide are

- Commercial nondispersive infrared spectrometer
- Sample Introduction System (including pump, flow control valve, and flowmeter)
- In-line filter (a filter with a porosity of 2 to 10 microns should be used to trap large particles)
- Moisture controller (refrigeration units or drying tubes).

The instruments are installed and connected in accordance with the manufacturers' specifications.

Evaluation and Interpretation of Data

Generally, carbon monoxide does not pose a health problem to the general public. Continuous exposure to CO concentrations of 10-15 ppm, however, can cause impaired time interval discrimination. CO levels of 30 ppm have caused physiologic stress in patients with heart disease, while concentrations of 8 to 14 ppm have been correlated with increased fatality rates in hospitalized myocardial infarction patients.

Geographical and Temporal Limitations

The concentration of carbon monoxide does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over

time. As such, substantial spatial and temporal variations in the concentration of carbon monoxide can be expected. It is generally claimed that the impact of carbon monoxide on the environment and man depends on the total amount of exposure over the entire year. The spatial variations can be accounted for by taking small units of urbanized regions for purposes of analysis. This would require extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial area.

Mitigation of Impact

There are three major strategies for the mitigation of impact of carbon monoxide on the environment. These are

- Control of motor vehicle emissions
- Control of station resource emission
- Reduction or removal of receptors from polluted areas.

Additional References

"Guidelines for Development of a Quality Assurance Program. Reference Method for Continuous Measurement of Carbon Monoxide in the Atmosphere", Environmental Protection Agency, August 1973.

PHOTOCHEMICAL OXIDANTS

Definition of the Attribute

Products of atmospheric reactions between hydrocarbons and nitrogen oxides which are initiated by sunlight are called photochemical oxidants. The product of these reactions which is most commonly found and measured in the atmosphere is ozone. Other oxidants of interest include peroxyacetyl nitrate (PAN) and acrolein. Atmospheric measurement techniques measure the net oxidizing properties of atmospheric pollutants and report these as photochemical oxidant concentrations as equivalent ozone concentration. Photochemical oxidants can be found anywhere where hydrocarbons and nitrogen oxides interact in the presence of sunlight.

Army Activities That Affect the Attribute

All Army activities that generate oxides of nitrogen and hydrocarbons simultaneously contribute to the generation of photochemical oxidants. Industrial operations of the Army, research/development/testing operations, operation and maintenance of motor vehicles and stationary combustion sources are sources of nitrogen oxides and hydrocarbons on a base. In addition, many Army activities have petroleum and petrochemical operations that emit high levels of hydrocarbons.

Source of Effects

The data from animal and human studies are sparse and inadequate for determining the toxicological potential of photochemical oxidants. Injury to vegetation is one of the earliest manifestations of photochemical air pollution. The oxidants can cause both acute and chronic injury to leaves. Leaf injury has occurred in certain sensitive species after a 4-hour exposure to 100 micrograms per cubic meter (0.05 ppm) total oxidants. Photochemical oxidants are known to attack certain materials. Polymers and rubber are important materials that are sensitive to photochemical oxidants.

Variables to be Measured

The variable measuring the extent of photochemical oxidants is the maximum 3-hour concentration (6:00 to 9:00 a.m.) not to be exceeded more

than once a year. The photochemical oxidant level is reported in micrograms per cubic meter.

How Variables are Measured

Since ozone is the major constituent contributing to photochemical oxidants, it is used as the reference substance in reporting levels of photochemical oxidants.

Ambient air and ethylene are delivered simultaneously to a mixing zone where the ozone in the air reacts with the ethylene to emit light which is detected by a photomultiplier cell. The resulting photocurrent is amplified and displayed on a recorder. The range of most instruments is from 0.005 ppm to greater than 1 ppm of ozone. The sensitivity is 0.005 ppm of ozone.

Data Sources. The sources of data are generally the State Pollution Control Department, the County Air Pollution Control Office, or the City Air Pollution Control Office. The Army can also install monitoring equipment at critical locations near its operations to determine the level of photochemical oxidants generated by its activities.

Skills Required. A basic paraprofessional training in mechanical or chemical engineering with special training in operating the air-quality instruments is adequate to collect data relating to photochemical oxidants. Specialized supervision will be needed to insure that the data are properly collected and analyzed. Specialized supervision should include trained and experienced personnel or experienced consultants in the field of air-quality monitoring.

Instruments. Instruments for carrying out the photochemical oxidant measurement include

- A detector cell
- An air flowmeter capable of controlling air flows between 0-1.5 liter per minute
- An ethylene flowmeter capable of controlling ethylene flows between 0-50 milliliter per minute
- An air inlet filter capable of removing all particles greater than 5 microns in diameter
- A photomultiplier tube
- A high-voltage power supply (2000 volts)
- A direct-current amplifier and a recorder.

Evaluation and Interpretation of Data

Photochemical oxidants are keyed to the 6:00 to 9:00 a.m. concentration values. At low concentrations photochemical oxidants do not pose a problem. The quality of the environment however rapidly deteriorates as conditions for smog development approach, i.e., hydrocarbon concentrations of 0.15 to 0.25 ppm. The values of the oxidant levels during the early morning determine the intensity of the oxidants to be expected later in the day. After sunset the oxidant concentrations are reduced to low levels.

Geographical and Temporal Limitations

The concentration of photochemical oxidants does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over time. As such, a substantial spatial and temporal variation in the concentration of photochemical oxidants can be expected. It is generally claimed that the impact of photochemical oxidants on the environment and man depends on the total amount of exposure during the peak periods. The spatial variations can be accounted for by taking small units of urbanized regions for purposes of analysis. This would require extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict the air-quality values over the entire spatial area.

Mitigation of Impact

All strategies for mitigating hydrocarbons and oxides of nitrogen are applicable to photochemical oxidants.

Additional References

"Guidelines for Development of a Quality Assurance Program. Reference Method for the Measurement of Photochemical Oxidant", Environmental Protection Agency, August 1973.

HAZARDOUS TOXICANTS

Definition of the Attribute

Many kinds of hazardous air pollutants may be released to the environment. Some of these toxic elements or compounds are arsenic, asbestos, barium, beryllium, boron, cadmium, chromium, copper, lead, molybdenum, nickel, palladium, titanium, tungsten, vanadium, zinc, zirconium, radioactive wastes, mercury, and phenols. These toxic substances at certain concentrations may cause serious damage to the health and welfare of an exposed community.

Hazardous toxicants are substances like asbestos, beryllium, mercury, other harmful elements, and their compounds. Man's exposure to these toxicants can cause serious health hazards and diseases. These health impairments can result in increased mortality, morbidity, susceptibility to diseases, and loss of productivity.

Army Activities That Affect the Attribute

Hazardous toxicants may be generated by Army activities such as construction, operation/maintenance/repair of existing systems, industrial operations, research/development/testing operations, and demolition of structures. For example, the surfacing of roadways with asbestos tailings can cause serious asbestos hazards.

The manufacture of clocks, cord, wicks, tubing, tape, twine, rope, thread, cement products, fireproofing and insulating materials, friction products, paper, mill-board, felt, floor tile, paints, coatings, caulks, adhesives, sealants, and plastics may produce visible emissions of asbestos. Also, construction emissions produce substantial amounts of asbestos dust.

Source of Effects

Hazardous toxicants can create serious health hazards and diseases of a chronic nature. For instance, exposure to asbestos dust at high concentrations and for longer durations can cause asbestos and bronchial cancer.[8] In addition, asbestos is a cause of mesothliomas; tumor; and membrane, intestine, and abdomen cancers. Most asbestos diseases have a latency period of 30 years.

To date, research has failed to establish an emission limit or concentration range above which asbestos dust can be harmful to human health. The Environmental Protection Agency, however, recommends that no visible emissions be permitted from asbestos-generating activities.

Beryllium is another hazardous air pollutant which can seriously affect human health. These effects are acute and chronic lethal inhalation, skin and conjuctival effects, cancer induction, and other beryllium diseases. The lowest beryllium concentration producing a beryllium disease was found to be greater than 0.01 microgram per cubic meter.[9] At a concentration of 0.10 microgram per cubic meter or above, a large majority of exposed persons will develop beryllium diseases.

Variables to be Measured

The variable measuring the extent of impact of a specific hazardous toxicant is given by the maximum concentration of a given toxicant averaged over a 30-day period. For example, beryllium concentrations are required not to exceed 0.01 microgram per cubic meter over a 30-day period. In the same vein, mercury concentrations should not exceed 1.0 microgram per cubic meter over a 30-day averaging period.

How Variables are Measured

There are many different methods of measuring various hazardous toxicants.

The standard methods for sampling hazardous toxicants in the ambient air are presented in the Standard Methods for Sampling Stack Particulate Matter.[10] Also, specific measurement techniques for beryllium and mercury are given in the *Federal Register*, April 6, 1973.

Data Sources. Only a few city, county, regional, and state agencies monitor hazardous toxicants and emissions. Monitoring of selected hazardous toxicants is occasionally done by the Environmental Protection Agency in cooperation with state or local agencies for selected periods at critical locations. Such monitoring is done only when a special hazardous toxicant is identified in a given region. Data on toxicant

monitoring are available from state and local air-pollution-control agencies when collected.

Skills Required. Skills required for the measurement of various hazardous toxicants measuring techniques are not well defined in the literature and require specialized supervision for use. Specialized consulting services are needed to implement these measurement techniques.

Instruments. Complex sampling trains have to be designed on a case-by-case basis for each hazardous toxicant in the environment. The full range of instrumentation necessary for measurement of each hazardous toxicant is described in some of the above-mentioned standard documents.

Evaluation and Interpretation of Data

There are no well-defined value functions available for the hazardous toxicants identified in the environment. Generally, for each hazardous toxicant it is possible to establish the upper and lower concentration limit of acceptability for the environment. The upper limit of acceptability is called the **permissible level**, the excess of which is considered highly undesirable and damaging to human health. On the other hand, the lower concentration limit of acceptability is called the **desirable level**, below which concentration of the quality of air can be considered ideal; that is, the value function equals 1.

Permissible and desirable limits have not generally been established for each of the known hazardous toxicants. The Federal Government has established standards for three major hazardous toxicants: asbestos, beryllium, and mercury. The above levels for each of these pollutants are as shown in Table A-3.

The environmental impact of proposed activities on hazardous toxicant level is measured by the change in the hazardous toxicant concentration (HTC). When the HTC changes to the extent that its rating remains unaltered (e.g., High Quality air remains High Quality), the impact is considered Insignificant. When a change in HTC is such that the rating changes by one step (e.g., between High Quality and Moderate Quality), the impact is treated as Moderate. When a change in HTC rating occurs through two steps (e.g., from High Quality to Poor Quality, or vice versa), the impact is considered Significant.

Table A-3. Hazardous Toxicant Value Functions

HTC Values (Value Function)	Hazardous Toxicant		
	Asbestos	Beryllium, mg/m^3	Mercury mg/m^3
Permissible level (0.5)	No visible emissions	0.10	0.1
Desirable level (1.0)	0.0	0.01	0.0
Dangerous level (0.0)	Visible	>0.10	>1.0

The hazardous toxicant value function, shown in Table A-3, is used to determine what quality rating should be given to a specific value of HTC. The following quality ratings are given to the HTC values:

Quality Rating	HTC Values
High Quality	Desirable level to less than Permissible level
Moderate Quality	Permissible level to less than Dangerous level
Poor Quality	Dangerous level

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of hazardous toxicants does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over time. As such, substantial spatial and temporal variations in the concentration of hazardous toxicants can be expected. It is generally claimed that the impact of hazardous toxicants on the environment and man depends on the total amount of exposure over the entire day. Spatial variations can be accounted for by analyzing small units of urbanized regions. This requies extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring program is infeasible in most situations, the problem can be adequately

addressed using diffusion models to predict air-quality values over the entire spatial area.

Mitigation of Impact

There are five major strategies for the mitigation of impacts resulting from hazardous toxicants:

- Removal of hazardous emissions
- Use of materials that do not generate hazardous toxicants
- Use of processes that do not generate hazardous toxicants
- Avoiding or reducing activities that generate hazardous toxicants
- Removing people from contaminated areas.

Other Comments

Hazardous toxicants are powerful damaging agents for a community. The Army can ill afford to be negligent about such emissions. Any attempt on the part of the Army to compel communities to endure dangerous levels of toxicants resulting from its activities should be strongly discouraged. The use of this parameter will help to identify potential hazardous toxicant problems resulting from various Army operations.

Additional References

ODORS

Definition of the Attribute

Industrial malodors are generally considered harmless, even though they frequently cause loss of personal and community pride, loss of social and economic status, discomfort, nausea, loss of appetite, and insomnia. It is true that odor effects on human health and welfare have been recognized only recently, and very little attention seems to have been given to this air contaminant in the literature.

Malodors are generally caused by organic and sulfur compounds. The resulting odor characteristics are described by commonly accepted odor descriptors. Some common odor descriptors and their odor contaminants are indicated in Table A-1. For each odor contaminant, a concentration can be defined for which there can be no perception of the odor by a panel of individuals. The concentration is generally known as **olfactory threshold** or **odor threshold.** The odor thresholds of a few selected gaseous sulfur compounds in the air are shown in Table A-2.

The odor intensity is a measure of the stimulus resulting from the olfactory sensation of a given concentration of odorant. According to the Weber-Fechner law, odor intensity increases only logarithmically with the increase in concentration of the odor.

Army Activities That Affect the Attribute

In general, the Army base industrial operations, research/development/testing operations, and operation/maintenance activities are potentially capable of emitting odor contaminants to the air.

Source of Effects

Malodors can affect both health and welfare of a community. These effects result from the loss of personal and community pride, lowering socioeconomic status, damaging community reputation, discouraging capital investment in a community, discouraging tourism, reducing property values, tarnishing silver and paints, corroding steel, reducing appetite, producing nausea and vomiting, causing headache, and disturbing sleep, breathing, and olfactory sensation. These result in significant impacts causing major public concern.

Table A-1. Selected Malodors and Contaminants

Chemical Compound or Type Material	Commonly Accepted Description of Odor Types
Acetaldehyde	Fruity
Acetic acid	Vinegar
Acetone	Nail polish remover
Acetylene	Ethereal, garlic
African fiber	Musty, sour
Banana oil	Nail polish remover
Burnt protein	Burnt toast, scorched grain
Cannery waste	Rotten egg
Carbon disulfide	Rotten egg
Carbon tetrachloride	Cleaning fluid
Cresol	Creosote
Decayed fish	Rendering
Dimethyl sulfide	Rotten vegetables
Enamel coatings	Fatty, linseed oil
Fatty acids	Grease, lard
Fermentation	Yeast or stale beer
Foam rubber curing	Sour sulfides
Gas house	Gas odors
Hydrogen sulfide	Rotten egg
Indole	Rest room
Iodoform	Iodine
Medicinal	Iodoform
Methyl ethyl ketone	Nail polish remover
Mercaptans (methyl)	Rotten cabbage
Oils: Castor, coconut, soya, linseed	Rancid grease
Phenolic	Carbolic acid
Phenolic resins	Carbolic acid
Pig pen	Waste lagoons
Pyridine	Acrid, goaty
Septic sewage	Rotten egg
Skatole	Rest room
Sludge drying	Burnt grain
Sulfur dioxide	Irritating, strong suffocating

Sources: Weisburd[6] and Post[7].

Variables to be Measured

There are two major variables that measure the extent of odor problems. First, the average annual concentration of selected odor contaminants in parts per million (ppm) by volume is a useful measure of the extent of odor pollution at a given receptor point in a community. Second, the odor intensity, determined by an "odor jury" consisting of a panel of eight persons, is another measure of odor problems. The odor intensity scale has the following levels:

Levels Descriptors

0 No odor
1 Odor threshold (or very slight odor)
2 Slight odor
3 Moderate odor
4 Strong odor.

The concentration and intensity variables are used interchangeably for odor measurements.

Table A-2. Odor Thresholds of Selected Gaseous Sulfur Compounds in Air, ppm (by volume)

Sulfur dioxide	1.0–5.0[a]		
Hydrogen sulfide	0.0047[a]	0.0085[b]	0.0009[d]
Methyl mercaptan	0.0021[a]	0.040[c]	0.0006[d]
Dimethyl sulfide	0.0001[a]	0.0036[c]	0.0003[d]

a Leonardis, G., Kendall, D., Barnard, N., "Odor Threshold Determinators of 53 Odorant Chemicals", J.A.P.C.A. (2), 91-5, 1969.

b Lederlof, R., Edfor, M. L., Friberg, L., Lindvall, T., *Nordisk Hygenish Tidskrfit*, 46, 51, 1965.

c Young, F. A., Adams, D. R., Sullivan, Dobbs, "The Relationship Between Environmental-Demographic Variables and Olfactory Detection and Objectionability Thresholds" to be published in *Perception and Psychophysics.*

d "Handbook of Air Pollution", U.S. DHEW, PHS, Bureau of State Services, Division of Air Pollution, Cincinnati, Ohio.

Source: Weisburd[6].

How Variables are Measured

Two distinct methods for measuring malodors are

Scentometer method
Odor judgment panel.

A scentometer can be used to measure ambient odor intensities when traveling through dusty areas. Strong, constant odors are measured by a scentometer over a square mile of area. It is a useful routine surveillance device that can identify threshold levels, possible odor-problem areas, patterns of peak odor intensity, etc., over a given region.

On the other hand, an odor judgment panel can be used to verify the source of an unidentified odor, odor intensity, and damage potential of a given odor.

Data Sources. The Federal Government has not yet established standards for potential odorants. No systematic monitoring and data collection are done with regard to odorants or odor contaminants by state and local agencies. Only in isolated cases will it be possible to find data on odor contaminants for selected periods and monitoring stations operated by state or local agencies.

Skills Required. The use of a scentometer requires at least a technician-level training and about a year's experience in using the equipment. The odor-panel approach does not require any specific qualifications or formal training. It requires careful selection of juries based on olfactory sensation, and continuous training of the jurors to develop proper perception of different types of odors.

Instruments. The scentometer is the only equipment that is required in the first method of measuring odor problems. The second method (i.e., odor-panel approach) does not require any equipment whatsoever.

Evaluation of Interpretation of Data

An environment with **no odor** at all is considered to be an ideal environment with an environmental quality value of 1.0. Odor threshold concentration represents a tolerable level of odor contamination in the air; as such it has an environmental quality value of 0.6. The value function falls rapidly with the occurrence of **slight odor**, and to 0 with a **strong odor**. Based on above considerations, the value function for various odorants is presented in Figure A-5. For practical purposes, **odor threshold** of any odorant is the odorant concentration that can be detected only by 5 to 10 percent of the panelists. The **slight odor** is detected by about 20 to 25 percent of the panelists. The **moderate odor** is detected by about only 40 percent of the panelists, and the **strong odor** is detected by about 100 percent of the panelists.

Special Conditions – (None)

Geographical and Temporal Limitations

Concentration of malodors does not remain constant over the entire spatial extent in a given region. Also, it will not remain constant over time. As such, substantial spatial and temporal variations in the concentration can be expected. Spatial variations can be accounted for by analyzing small units of urbanized regions. This requires extensive calculations based on a diffusion model or a large-scale monitoring program. Since the use of a large-scale monitoring network is infeasible in most situations, the problem can be adequately addressed using diffusion models to predict air-quality values over the entire spatial area.

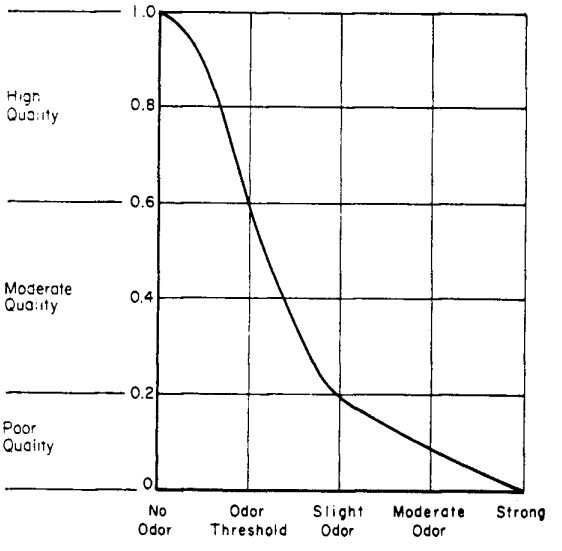

Figure A-5. Odor Value Function

The environmental impact of proposed activities on odor level is measured by the change in odor intensity. When the odor intensity changes to the extent that its rating remains unaltered (e.g., High Quality air remains High Quality), the impact is considered Insignificant. When the change in odor intensity is such that its rating changes by one step (e.g., between High Quality and Moderate Quality), the impact is treated as Moderate. When a change in odor rating occurs through two steps (e.g., from High to Low Quality, or vice versa), the impact is considered Significant.

The odor value function (Figure A-5) is used for rating air quality in terms of High, Moderate, and Low Quality based on measured odor intensity. For a given value of odor intensity on the horizontal axis, a point on the curve can be found which identifies the

environmental quality rating from the vertical axis of Figure A-4 (e.g., odor intensity of **slight odor** indicates a Moderate Quality of greater than 0.2).

Mitigation of Impact

The many different methods of abating potential impacts of odorous contaminants include

- Dilution of odorant (dilution can change the nature as well as strength of an odor)
- Odor counteraction of neutralization (certain pairs of odors in appropriate concentrations may neutralize each other)
- Odor masking or blanketing (certain weaker malodors may be suppressed by a considerably stronger good odor)
- Reduction in odor emissions
- Removal of receptors from polluted areas and/or from downwind odor path
- Fatigued olfactory odor perception (certain levels of odor can be tolerated as a result of perception fatigue due to long-term exposure to the odor).

Planning can help establish optimal combinations of these mitigation alternatives to ensure that the best solution is made available to a community.

Other Comments – (None)

Additional References

REFERENCES

(1) Jain, R. K., et al., *Environmental Assessment Impact Study for Army Military Programs,* U.S. Army Construction Engineering Research Lab., Report CERL-IR-D-13 (December 1973).

(2) Environmental Protection Agency, *Federal Register,* Volume 36, Number 84, Friday, April 30, 1971, National Primary and Secondary Ambient Air Quality Standards.

(3) *Air Quality Criteria for Sulfur Oxide,* U.S. Department of Health, Education, and Welfare, Washington, D. C., March 1970.

(4) *Air Quality Criteria for Hydrocarbons,* U.S. Department of Health, Education, and Welfare, March 1970.

(5) *Air Quality Criteria for Nitrogen Oxides,* U.S. Department of Health, Education, and Welfare, March 1970.

(6) Weisburd, N. I., *Field Operations and Enforcement Normal for Air Pollution Control,* Volume 3, Environmental Protection Agency, August 1972.

(7) Post, N. K., "Odor Control of Wastes", *Industrial Waste Disposal,* Editor: R. D. Ross, Reinhold Book Corp., New York, 1968.

(8) Environmental Protection Agency, *National Emission Standards for Hazardous Air Pollutants, Federal Register,* Volume 38, Number 66, April 6, 1973.

(9) Eisenbud, N., et al., "Nonoccupational Beryllliosis", *Journal of Ontological Hygiene and Toxicology,* Volume 31, 1949.

(10) "Standard Method for Sampling Stack Particulate Matter", *1971 Book of ASTM Standards,* Part 23, Philadelphia, 1971 (ASTM, Designation -2928-71).

A necessity for life
A transporter of disease
A sustainer of navigation
A coolant, cleanser, diluent
A medium for recreational pursuits
A resource with food for populations
A power source to harness and control
A source of tranquil, aesthetic equipment
A refuge for biological pests and nuisances
A defiled purveyor of civilization's wastes.

Water means different things to different people. A particular definition depends in large measure on the personal uses to which water is put by the definer.[1]

Pollution of water is impairment of water quality by man's activity causing an actual hazard to public health or impairment of beneficial use of water.

The water environment is an intricate system of living and nonliving elements. Physical, chemical, and biological factors influencing water quality are so interrelated that a change in any water-quality parameter triggers other changes in a complex network of interrelated variables. Often it is difficult to categorize the nature of these interrelationships that may result from man's activity and influence on the entire water system.

The Environmental Impact Study for Army Military Programs[2] conducted by CERL has identified 81 attributes of the environment for surface water and 58 attributes for groundwater which could be used to determine the impact of Army programs. Although each of these attributes represents a unit of water system worthy of separate consideration, it may constitute a very complex system for analysis. To simplify the analysis, the attributes of a similar nature have been grouped together. This grouping was done with the following objectives in mind. The list of selected attributes should be:

- As compact as possible
- Equally applicable to surface and groundwater quality
- Representative of comprehensive water-quality indicators
- Measurable in the field
- Relevant to Army functional areas
- Capable of being measured on a project scale.

Self-Purification of Natural Waters

All natural waters have the capability to assimilate certain amounts of waste without apparent effect upon the environment. The process by which self-purification is achieved is different for surface-water and groundwater systems. Both types of water systems are briefly described below.

Surface-Water System

Some minor degradation of surface-water quality may be overcome by the natural capacity of water bodies for withstanding certain insults. Such natural capacity is a result of dilution, sedimentation, flocculation, volatilization, biodegradation, aeration, aging, and uptake by organisms. The effects of relatively small amounts of waste are mitigated and the water system recovers itself. If the waste load is excessive, even for a short period, the effects may be devastating. The process of self-purification in surface waters is a complex phenomenon. Readers are referred to several excellent sources of information.[1]

Groundwater System

Pollution of groundwater systems is relatively difficult. Contaminants have to travel through a soil column before any pollution is caused. Many soils have the capability to mitigate many types of wastes. The processes by which waste is purified in the soil column are aerobic and anaerobic decomposition, filtration, ion exchange, adsorption, absorption, etc. The process of dilution also reduces the concentration of contaminants.

Many contaminants are frequently removed during movement of water through the soil (unless the groundwater is directly contaminated by fissure cracks, leaks, pipes, or holes). Examples of such contaminants are microorganisms, organic matter, and turbidity. Only dissolved solids and gases are of significant importance in groundwater pollution. These contaminants, as discussed later, cause taste, odor, and physiological effects.

Table A-4. Selected Attribute and Environmental Impact Categories

Selected Attributes	Observed Condition	Environmental Impact Category[1]				
		1	2	3	4	5
Physical						
Aquifer Safe Yield[2]	Changes occurring in physical attributes of aquifer (porosity, permeability, transmissibility, storage coefficient, etc)	No Change	No Change	Slight Change	Significant Change	Extensive Change
Flow Variation[3]	Flow variation attributed to activities; $\frac{Q_{max}}{Q_{min}}$	None	None	Slight	Significant	Extensive
Oil[4]	Visible silvery sheen on surface, oily taste and odor to water and/or to fish and edible invertibrates, coating of banks and bottom or tainting of attached associated biota	None	None	Slight	Significant	Extensive
Radioactivity[4]	Measured radiation limit 10^{-7} micro curie/ml	Equal to or Less	Equal to or Less	Exceed Limit	Exceed Limit	Exceed Limit
Suspended Solids[3]	1. Sample observed in a glass bottle	Clear	Clear	Fairly Clear	Slightly Turbid	Turbid
	2. Turbidity in Jackson turbidity units	3 or Less	10	40	60	140
	3. Suspended solids mg/l	4 or Less	10	15	20	35
Thermal Discharge[3]	Magnitude of departure from natural condition C	0	2	4	6	10

Chemical Acid & Alkali[4]	Departure from natural condition, pH units	0	1	2	3	4
BOD[4]	mg/l	1	2	3	5	10
DO[3]	% saturation	100	85	75	60	Low
Dissolved Solids[4]	mg/l	500 or Less	1000	2000	5000	High
Nutrients[3]	Total Phosphorus mg/l	0.02 or Less	0.05	0.10	0.20	Large
Toxic Compounds[4]	Concentration mg/l	Not Detected	Traces	Small	Large	Large
Biological Fecal Coliforms[4]	Number per 100 ml	50 or Below	5000	20,000	250,000	Large
Aquatic Life[3]	Green Algae	Scarce	Moderate Quantities in Shallows	Plentiful in Shallows	Abundant	Abundant
	Grey Algae	Scarce	Scarce	Scarce	Present	Plentiful
	Delicate fish; trout, grayling	Maybe Plentiful	Plentiful	Probably Absent	Scarce	Absent
	Coarse fish; chub, dace, carp, roach	Maybe Present	Plentiful	Plentiful	Scarce	Absent
	Mayfly naiad, stonefly nymph	Maybe Plentiful	Plentiful	Scarce	Absent	Absent
	Blood worm, sludge worm, midge larvae, rat-tailed maggot, sewage fly larvae and pupa	Maybe Absent	Scarce	Maybe Present	Plentiful	Abundant

Notes: (1) Environmental Impact Category; Category 1 indicates most desirable condition; Category 5 indicates extensive adverse condition. Because all attributes are related to environmental quality between 0 and 1 it is possible to compare different attributes and five categories on a common base. Each category is equivalent to approximately 20% of overall environmental quality. In the physical sense, water quality for five categories will be very clean, clean, fairly clean, doubtful and bad. Environmental impact may be adverse or favorable. Adverse impact will deteriorate the environmental quality while favorable impact will improve the quality. Proper signs and weights must be used to achieve overall effects.

(2) Applies to ground water systems only.

(3) Applies to surface water systems only.

(4) Applies to both the ground water and surface water.

When groundwater becomes contaminated, water purification is a difficult problem. Due to the relative low-flow rates of groundwater systems, pollutants are not readily diluted and thus tend to remain localized problems for a period of time. There is also a considerable lag time before that pollution becomes noticeable in a groundwater system. As a result, today's activity may show impact only after several years.

Description of Selected Water-Quality Attributes

Fourteen attributes define potential effects on water quality from the basic activities associated with Army programs. These attributes, in three major categories, physical, chemical, or biological, are listed below:

- Physical
  - Aquifer Safe Yields
  - Flow Variations
  - Oil
  - Radioactivity
  - Suspended Solids
  - Thermal Pollution
- Chemical
  - Acid and Alkali
  - Biochemical Oxygen Demand (BOD)
  - Dissolved Oxygen (DO)
  - Dissolved Solids
  - Nutrients
  - Toxic Compounds
- Biological
  - Aquatic Life
  - Fecal Coliform.

Table A-4 is a summary table indicating the 14 water-quality attributes, conditions contributing to each, and a useful scale of impacts.

AQUIFER SAFE YIELD

Definition of the Attribute

Aquifer* safe yield describes the general availability of the total groundwater system to supply water for human uses without the ultimate depletion of the aquifer. Aquifer safe yield includes all physical attributes of aquifer, which are, porosity, permeability, transmissibility (which is permeability times thickness of the aquifer), and storage coefficient.

Army Activities That Affect the Attribute

Many Army activities affect the aquifer yield. The aquifer safe yield (available water resource) may decrease due to overpumping or by restricting this movement of water into or through the aquifer. During overpumping as a result of turbulences in the well bore, fine-grained material moving near the well causes a decrease in water movement toward the well. Land-use patterns may significantly reduce the water percolation into the ground. Also, improper waste injection may cause clogging of the formation due to suspended solids or bacterial action. Leaching of landfills may also clog the pores. All these factors decrease transmissibility of an aquifer and result in decreased aquifer safe yield. In regions dependent upon groundwater for water supplies, a decrease in safe yield could be highly undesirable. Lowering of the water table may cause public controversy even in regions almost wholly dependent upon surface waters as a water supply. In coastal regions, uncontrolled water pumping from the ground may reverse the normal seaward gradient of the water table and permit saltwater to move inland and contaminate the aquifer.

Many Army activities may increase water availability due to increased water entering the system which may result in raising of the water table accompanied by increased aquifer safe yield. Examples of such activities are water impoundment and reservoir construction and changes in topography to increase percolation. High water table is often accompanied by water-logging problems in soils and water problems during excavation.

*An aquifer is defined as an earthy material capable of yielding water to a well in usable quantities.

Source of Effects

As discussed above, many Army activities may upset the aquifer yield by directly or indirectly altering physical factors such as permeability, porosity, and ground surface conditions. The effects may be damaging, and reduce potential groundwater resources.

Variables to be Measured and How Variables are Measured

Maximum safe yield is measured in thousands of acre-feet of water withdrawn in a unit of time (usually in a year); the method of measurement is based upon several techniques which all utilize extensive pumping tests.

Evaluation and Interpretation of Data

Knowledge concerning the relationship between degree of change in aquifer safe yield and the environmental impact is extremely limited. It would not be possible at this time to make any quantitative judgment. However, since the reasonable environmental goal is to minimize the impact, a qualitative judgment can be made which relates to deviation from the natural condition. Table A-4 summarizes five degrees of environmental impacts based upon the qualitative judgments.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

All Army activities that are likely to change the physical nature of the aquifer, to affect land-surface runoff and percolation, and in general, to increase or decrease water availability to the aquifer should be carefully controlled. Included are land-use pattern, landfilling, lagooning, reservoir construction, deep-well injection, and pumping rate. Complete tests should be made to investigate the existing groundwater hydrology and correctional techniques in relation to land slope and topography; surface area; reservoir, lagoon, and landfill lining; and restricting deep-well injection. Pumping rate should be employed to minimize the impact.

Other Comments – (None)

Additional References

FLOW VARIATIONS

Definition of the Attribute

The velocity of flow and discharge are extremely important to aquatic organisms in a number of ways including the transport of nutrients and organic food past those organisms attached to stationary surfaces; the transport of plankton and benthos as drift, which in turn serve as food for higher organisms; and the addition of oxygen to the water through surface aeration. Silts are moved downstream and sediments may be transported as bed load. These in turn are often associated with major nutrients, such as nitrogen and phosphorus, which may be released at some point downstream.

Natural flow variations are, therefore, critical factors governing the type of ecological system that will develop and survive in a given watercourse. If the pattern of stream-flow variation is changed markedly from that which is natural, subsequent disruption of the natural ecology may result.

Army Activities That Affect the Attribute

Major activities that may influence stream flow are reservoir projects, and changing the ground surface and topography for different types of land-use projects. This may include site clearing, earthwork and borrowing, paving of land areas, and building construction.

Source of Effects

Reservoir projects may be flood control (that reduces high flows), power generation (that minimizes low-flow conditions), or any desired use that alters the flow pattern of the stream. The land-use project alters the runoff, percolation, and evaporation in the drainage basin. These changes may increase or decrease the runoff. Other attributes affected by such activities are suspensoided solids and nutrients in the watercourses; they may in turn affect the population of photosynthetic organisms and thus the food chain.

Variables to be Measured and How Variables are Measured

Flow measurement is simple. Many types of automatic flow-measurement devices are commercially available that can be installed in a selected reach of a watercourse. The unit of flow measurement is cubic feet per second (CFS).

Evaluation and Interpretation of Data

If flow variations are rapid and extensive, more disruption to natural ecology results. However, due to lack of information, classification of water cannot be made on the basis of qualitative measurement. Five degrees of environmental impact are summarized in Table A-4. This classification is based upon qualitative or observed conditions.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

All Army activities such as land-use projects and water impoundment and operation should be given consideration to minimize flow variations from the mean natural flow.

Other Comments – (None)

Additional References

OIL

Definition of the Attribute

Oil slicks are barely visible at a concentration of about 25 gallons/square mile. At about 50 gallons per square mile, an oil film is about 3.0×10^{-6} inch thick and is visible as a silvery sheen on the surface. Oil is destructive to aquatic life in the following ways:

- Free oil and emulsions may coat and destroy algae and plankton
- Heavy coating may interfere with the natural process of reaeration and photosynthesis
- Water-soluble fractions may exert a direct toxic action
- Settleable oil substances may coat the bottom, destroy benthic organisms, and interfere with spawning areas.

Army Activities That Affect the Attribute

Major Army activities responsible for oil pollution include bilge and ballast waters from ships; oil refinery wastes; industrial plant wastes such as oil, grease, and fats from the repair shops, and lubrication of machinery; gasoline filling stations; bulk stations; and accidental spills.

Source of Effects

Oil may reach natural waters by direct discharge or by surface runoff. Direct discharge may occur from bilge and ballast waters or accidental spill from barges or tankers. Indirect oil release may occur from surface runoff or storm sewers, and combined sewer overflows. In all cases, damage could be severe and long lasting. Water-quality parameters affected by oil discharge are dissolved oxygen, general appearance, and taste and odor.

Variables to be Measured and How Variables are Measured

Dissolved or emulsified oil or grease is extracted from water by intimate contact with various organic solvents. The results are expressed mg/l oil or grease. Other measurements are qualitative and include (1) visible oil slick, (2) oily taste and odor of fish and edible invertebrates, and (3) coating of banks and bottom or tainting of associated biota. Quantitative measurement of oil and grease is by extraction in a separating funnel with either trichlorotrifluorethane or petroleum ether. The technique is used as routine analysis in water and wastewater analysis.

Evaluation and Interpretation of Data

Due to lack of information, classification of water cannot be made on the basis of quantitative measurement or concentrations. Five degrees of water impacts are summarized in Table A-4 on the basis of qualitative or observed conditions.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Oil pollution can be minimized by controlling all direct discharge into natural waters. Surface runoff from oil handling areas should be treated for oil separation before discharge into the environment. If oil wastes are combined with sanitary sewage, oil separation will be necessary at the wastewater treatment facility. Lagooning of oil wastes and land disposal of oily sludges should be restricted to avoid possible contamination of the groundwater system.

Other Comments – (None)

Additional References

RADIOACTIVITY

Definition of the Attribute

Ionizing radiation, when absorbed in living tissue in quantities substantially above that of natural background, is injurious. It is, therefore, necessary to prevent excessive levels of radiation from reaching any organism, be it human, fish or invertebrate.

Army Activities That Affect the Attribute

Army activities responsible for radiation hazards are application of nuclear methods in power development, industrial operation, medical laboratories, research and development, nuclear weapon testing, and radiation warfare. In all applications, radioactive substances may be released accidentally, by inadequately planned and controlled activity, or by disposal of radioactive wastes.

Source of Effects

Radioactivity once released to the aquatic environment may (1) remain in solution or in suspension, (2) precipitate and settle to the bottom, or (3) be taken up by plants and animals. Immediately upon introduction of radioactive materials into the water, the wastes may become diluted by dispersion or may become concentrated by the process of biological magnification.*

Variables to be Measured and How Variables are Measured

The measure of radioactivity in **curie** which is the quantity of any radioactive material in which the disintegrations per second are 3.70×10^{10}. This is a large amount of radioactivity. Two smaller units – microcurie (10^{-6} curie) or picocurie (10^{-12} curie or 2.22 disintegrations per minute) are often used. Radioactive waste can be diluted in water to below the allowable limit. The allowable limit of radiation in natural water is taken as 10^{-7} microcurie per ml when the activity is caused by an unknown mixture of beta- and gamma-emitting isotopes.

Measurement techniques are not difficult because radiation-counting equipment of high sensitivity and stability is commercially available.

Evaluation and Interpretation of Data

It is not easy to determine the long-term effects of the radiological wastes upon aquatic life. For this reason and as a practical matter, radioactivity exceeding the allowable limit of 10^{-7} microcurie per ml may be considered detrimental to human health and aquatic life. Five classes of water impacts are given in Table A-4.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Release of radioactive wastes from radiation facilities must be monitored and controlled. Radioactivity in sewage after treatment is reduced in unknown amounts through concentration in sludge. However, sludge disposal becomes a difficult problem. Therefore, waste containing radioactivity should be treated separately by means of dewatering processes and solids or brine should be disposed of by special care (deepwell – injection of containment). Fallout of radioactive dust will induce radioactivity in surface runoff, treatment of which is a difficult task. All efforts should, therefore, be made to minimize release of radioactivity into the environment.

Other Comments – (None)

Additional References

*This is a process by which some substances become concentrated instead of dispersed with each link in the food chain

SUSPENDED SOLIDS

Definition of the Attribute

Suspended solids are solids contained in water which are not in solution. They are distinguished from dissolved solids by laboratory filtration tests. Suspended solids comprise settleable, floating (specific gravity – lower than water), and nonsettleable (colloidal suspension) components. These may contain organic (volatile suspended solids) or inert (nonvolatile) substances. Turbidity may be caused by a wide variety of suspended materials which range in size from colloidal particles to a coarse dispersion, depending upon the turbulence.

Suspended solids are perhaps of greatest significance from the standpoint of aesthetics. Natural waters may contain wide variations of suspended solids. These may be due to clay, silt, silica, organic matter, microorganisms, or sewage. Suspended solids may be undesirable in many ways. In public water supplies, turbid water is difficult and costly to filter. Disinfection may require higher chemical dosages if the water is turbid. Also, excessive suspended solids can be harmful to fish and other aquatic life by coating gills, blanketing bottom organisms, reducing solar radiation intensity, and, thus, affecting the natural food chain. In stream-pollution-control work, all suspended solids are considered to be settleable solids as (by bacterial decomposition and chemical flocculation) those solids eventually are deposited.

Army Activities That Affect the Attribute

Army activities directly responsible for suspended-solids release are dredging, wastewater discharge, construction of hydraulic structures, and gravel washing. Activities that indirectly affect suspended solids result from land use. Site clearing, surface paving, building construction, landscaping, and mine tailings. All change the surface runoff pattern which in most cases increases the storm flow. Suspended-solid load in the surface runoff may change considerably due to erosion. Also, flow variations in streams may change the bed load and solids transport.

Source of Effects

As discussed above, many Army activities will increase or decrease the suspended-solid condition in natural waters. It may be mentioned that many times this effect may be temporary. For example, dredging may increase suspended solids during operation. After completion of dredging, the channel may become deeper and wider which may actually reduce velocity and encourage settling. Likewise, many other activities such as construction, site clearing, and excavation may have effects that should be evaluated as long- or short-term effects.

Many water-quality attributes may be affected by a change in suspended-solid condition. These include DO (due to increase in photosynthesis), nutrient enrichment, direct deleterious effect to fish and other aquatic life, e.g., by coating gills or blanketing bottom organisms.

Variables to be Measured and How Variables are Measured

Settleable suspended solids are measured in mg/l of settled water. Suspended solids are measured by filtering a sample through a membrane filter or an asbestos mat in a Gooch crucible. Turbidity is measured in Jackson units equivalent to the interference to light transmission caused by 1 mg/l of a standard suspension.

Many types of commercially available instruments can continuously measure and record the turbidity and suspended solids in water. They all rely upon passage of light through a standard light path.

Evaluation and Interpretation of Data

Water quality is considered lower with increasing turbidity and suspended solids. Table A-4 summarizes the five classes of water impact based upon turbidity, suspended solids, and visual consideration.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

The impact due to suspended solids may be minimized by controlling discharge of wastes that contain suspended solids. This includes sanitary sewage and industrial wastes. Also, all activity that increases erosion or contributes nutrients to water (thus stimulating algae growth) should be minimized.

The gravel washing activity, mine tailings, and anything causing dust may also be controlled.

Other Comments – (None)

Additional References

THERMAL DISCHARGE

Definition of the Attribute

Temperature is a prime regulator of natural processes within the water environment. It governs physiological function in organisms and, acting directly or indirectly in combination with other water-quality constituents, affects aquatic life with each change. Water temperature controls spawning and hatching, regulates activity, and stimulates or suppresses growth and development; it can kill when the water becomes heated or chilled too suddenly. Colder water generally suppresses development; warmer water generally accelerates activity.

Army Activities That Affect the Attribute

Army activities affecting the attribute are discharges of cooling water. The cooling water may result from sources such as thermal power generation, heavy-machine operations, and industrial operations.

Source of Effects

Heated wastes when discharged into the water environment raise its temperature. The extent to which the temperature is raised depends upon the quantity of waste heat discharged and the amount of diluting water available. As water temperature increases, the solubility of oxygen decreases. Furthermore, the accelerated biological activity imposes higher oxygen demand. The net result is a decrease in DO level which can reach critical levels.

Variables to be Measured and How Variables are Measured

Temperature measurement is simple and accurate. Many types of automatic temperature recording devices are commercially available. Measurement scale is either degrees centigrade or Fahrenheit.

Evaluation and Interpretation of Data

In environmental-quality assessment, the temperature effects are best handled in terms of the magnitude of departure from the natural conditions. Table A-4 summarizes five classes of water impacts based upon temperature rise above natural conditions. The possibility of lowering the temperature due to Army activity is very remote and, therefore, ignored.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Cooling towers can be used to convert once-through systems into a closed system. A very efficient way is to utilize treated wastewaters (such as sewage, industrial wastes, or stored surface runoffs) as cooling water makeup. Many industrial plants are considering such a closed system. Chromium may be recovered from cooling tower blowdown before treatment and disposal of tower blowdown.

Other Comments – (None)

Additional References

ACID AND ALKALI

Definition of the Attribute

Acid and alkaline wastes discharged into waters may change the natural buffer system. pH of the water may significantly change depending upon the extent of acid or alkali discharged. Change in pH of natural water is hazardous for fish and other aquatic life. Below a pH of 5.0 and above 9.0, fish mortalities may be expected.

Army Activities That Affect the Attribute

Army activities which may contribute acid and alkali waste to the environment are industrial wastes such as pickle liquors, accidental spills of chemicals, and mining operations.

Source of Effects

Acid and alkali wastes can be extremely damaging to aquatic life. Toxicants due to the presence of heavy metals is increased by synergism. Also, the capacity of natural waters to assimilate organic wastes is significantly reduced by these wastes.

Variables to be Measured and How Variables are Measured

pH is considered the best measure of environment quality. High pH reflects an alkaline situation and low pH reflects an acid condition (a neutral solution has a pH equal to 7.0).

pH measurement is simple. Many types of continuous measuring and recording instruments are commercially available for this purpose.

Evaluation and Interpretation of Data

Since the natural pH of aquatic ecosystems varies from one locale to another, the best measure of pH is in terms of departure from natural levels. Table A-4 summarizes five classes of water impacts based upon pH departure from the normal. It has been assumed that both positive and negative departures are equally damaging to the water environment. This may not be strictly true in normal cases, but due to lack of evidence such assumption may be considered valid.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Neutralization of all acid- and alkali-containing waste is necessary to avoid damage to the environment. The drainage from mined or any other areas should be collected and neutralized before discharge.

Other Comments – (None)

Additional References

BIOCHEMICAL OXYGEN DEMAND (BOD)

Definition of the Attribute

BOD of water is an indirect measure of the amount of biologically degradable organic material present. It is, thus, an indication of the amount of dissolved oxygen (DO) that will be depleted from water during the natural biological assimilation of organic pollutants. The BOD test is widely used to determine the pollutional strength of sewage and industrial wastes in terms of oxygen that would be required if these wastes were discharged into natural waters in which aerobic conditions exist. The test is one of the most important in stream-pollution-control activities. By its use, it is possible to determine the degree of pollution in natural waters at any time. This test is also of prime importance in regulatory work and in studies designed to evaluate purification capacity of receiving bodies of water.

Army Activities That Affect the Attribute

Army activities associated with operation, maintenance, and repair may contribute to BOD wastes. These activities, in many respects, are similar to activities associated with running a small city, e.g., sanitary sewage, wastewaters from hospitals, food-handling establishments, laundry facilities, and floor washing from shops constitute BOD wastes. If all wastes are collected by a network of sewers to a central location, adequate treatment must be provided to minimize impact upon the surface-water system. If cesspools, septic tanks, and soakpits are utilized, groundwater in the vicinity may become adversely affected.

Source of Effects

The discharge of wastes containing organic material imposes oxygen demand in the natural body of water and reduces the DO level. If wastewaters are treated, the combined sewer overflows and surface runoffs may also exert effects under wet-weather conditions. All parameters directly or indirectly related to DO also affect the organic-waste assimilation. These parameters include depth of water, velocity of flow, temperature, and wind velocity (see section on DO for general discussion).

Variables to be Measured and How Variables are Measured

BOD values are generally expressed as the amount of oxygen consumed (mg/l) by organisms during a 5-day period at 20 C. Several other parameters such as Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC) are also used to represent the organic matter in water and wastewater. COD value indicates the total amount of oxidizable material present and includes BOD. TOC is a measure of bound carbon. Both these tests are closely related to BOD and are used in water- and wastewater-monitoring programs.

Routine BOD measurements are made in laboratories by dilution techniques and take 5 days to obtain the results. Some modifications of BOD tests may require less time. COD and TOC measurements take only a few hours. Several types of instruments are commercially available which measure TOC more or less on a continuous basis.

Evaluation and Interpretation of Data

Table A-4 indicates five classes of water: very clean, clean, fairly clean, doubtful, and bad, depending upon the BOD of water. It may be mentioned, however, that this classification must be used on relative terms. As an example, a sluggish stream, reservoir, or lake may show undesirable conditions at BOD of 5 mg/l, whereas a swift mountain stream may easily handle 50 mg/l of BOD without significant deleterious effects.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

All wastes containing organic wastes should be processed by treatment methods. The treatment methods may include biological or chemical processes. Also, several types of packaged treatment units are commercially available that can be installed for desired applications.

Other Comments – (None)

Additional References

DISSOLVED OXYGEN (DO)

Definition of the Attribute

All living organisms depend upon oxygen in one form or another for their metabolic process. Aerobic organisms require DO and produce innocuous end products. Anaerobic organisms utilize chemically bound oxygen, such as that from sulfates, nitrates, and phosphates, and the end products are odorous. For a diversified warm-water biota, including game fish, DO concentration should remain above 5 mg/l. Absence of DO will lead to the development of anaerobic conditions with odor and aesthetic problems. In surface waters, DO is measured frequently to maintain conditions favorable for the growth and reproduction of fish and other favorable aquatic life.

Army Activities That Affect the Attribute

The functional areas discussed in BOD also apply to DO. Other Army activities that may influence DO include site preparation demolition, dredging, and excavation, all of which may cause turbidity and nutrient release. Routine base operations such as operation and maintenance of aircraft and automotive equipment may cause oil release. Oil film interferes with the natural process of reaeration.

Source of Effects

Discharge of all organic wastes will lower the DO in receiving waters. A shallow and swift mountain stream can assimilate large quantities of organic wastes without deleterious effects. This is because swift-moving streams have greater capacity for natural reaeration and for preventing deposition of organic materials at the stream bed. In a sluggish stream or reservoir, small amounts of BOD released may cause relatively large adverse effects. The solubility of oxygen in water decreases with increases in temperature and dissolved salts (in freshwater solubility of oxygen at 0 C is 14.6 mg/l, and at 35 C, it is 7 mg/l). Biological activity is also increased at higher temperatures; thus the rate of DO utilization from natural waters is significantly increased. Thus, BOD wastes discharged into natural waters have more pronounced effects during summer months when the water is warm. Thus, water-quality parameters such as temperature, dissolved salts, depth and velocity of stream, wind velocity, and natural reaeration are all

interdependent. Also in nutrient rich bodies of water, due to algae bloom, the DO level may reach supersaturation during sunny days. At night, however, the DO level drops considerably due to lack of photosynthesis. High turbidity in water may also interfere with photosynthesis by reducing the depth of light penetration. Oil slicks may also reduce the natural reaeration process. Therefore, nutrients, algae, sunny days, turbidity, and oil slicks are all interdependent parameters.

Variables to be Measured and How Variables are Measured

The unit of DO measurement is in mg/l. It can be measured by titration techniques using the Azide Modification method. Many commercially available DO meters can be used for DO measurement.

Evaluation and Interpretation of Data

The oxygen requirements for fish vary with species and age. Cold-water fish require higher oxygen concentration than do the coarse fish (carp, pike, eel). It may be stated that the 3 to 6 mg/l range is the critical level of DO for nearly all fish. Below 3 mg/l, further decrease in DO is important only insofar as the development of local anaerobic conditions are concerned; the major damage to fish and aquatic life will already have occurred. Above 6 mg/l, the major advantage of additional DO is as a reservoir or buffer to handle shock loads of high oxygen demanding waste loads. Table A-4 indicates five classes of water according to DO levels.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

The methods are the same as those given for BOD.

Other Comments – (None)

Additional References

DISSOLVED SOLIDS

Definition of the Attribute

High amounts of total dissolved solids (TDS) are objectionable because of physiological effects, mineral tastes, or economic effects. TDS is the aggregate of carbonates, biocarbonates, chlorides, sulfates, phosphates, nitrates, and other salts of calcium, magnesium, sodium, potassium, and other substances. All salts in solution change the physical and chemical nature of the water and exert osmotic pressure; the magnitude of the change is to a large extent dependent upon the total salt concentration or salinity.

Army Activities That Affect the Attribute

Major Army functional areas which may contribute to TDS including mining and quarrying, municipal and industrial waste disposal, brine disposal, lagooning, landfilling of solid wastes, and accidental spill of chemicals.

Source of Effects

Major Army activities listed above may cause release of salts either directly or indirectly into the natural water system. Direct release includes discharging the waste laden with salts into the water system. Indirect release may be due to runoff from the affected land or seepage from filled areas. Landfill seepage or leaching may affect groundwater quality or surface water if groundwater feeds the water courses.

As a result of salt discharge, many water-quality parameters will be affected. DO will decrease as a result of high salinity. High quantities of salts give mineral taste. Sulfates and chlorides are associated with corrosion damage. Sulfate in water has a laxative effect. Nitrate plus nitrite causes methomoglobinemia (blue baby disease). Water containing high TDS also exhibits hardness.

Variables to be Measured and How Variables are Measured

Total dissolved solids is determined after evaporation of a sample of water and its subsequent drying in an oven at a definite temperature. This includes "nonfilterable residue". The results are expressed in mg/l TDS.

Evaluation and Interpretation of Data

For reasons of palatability and unfavorable physiological reaction, a limit of 500 mg/l TDS in potable water has been recommended. Highly mineralized waters are also unsuitable for many industrial applications. Irrigation crops are highly sensitive to salt concentrations; waters containing over 2000 mg/l are of marginal value for irrigation use, and waters containing 3000 mg/l are unsuitable. The upper limits for some freshwater fish are as high as 5000 mg/l. In such cases, reference is only to total salt concentration and its effects on osmotic pressure. Based upon TDS, the five impact classes are summarized in Table A-4.

Special Conditions

The amount of dissolved ionic matter in a sample may often be estimated by multiplying the specific conductance by an empirical factor. After the empirical factor is established, for a comparatively constant water quality, specific-conductance measurement will yield TDS. Specific-conductance measurement is relatively simple and is a measure of a water's capacity to convey an electric current at 25 C. Specific conductance is expressed as micromhos/cm.

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Wastes containing high TDS are difficult to treat. Recommended treatment methods include removal of liquid and disposal of residue by controlled landfilling to avoid any possible leaching of the fills. Deep-well injection has been used for disposal of brine. All surface runoffs around mines or quarries should be collected and concentrated. The brine may be disposed of by deep-well injection or other means acceptable to water quality control authorities.

Other Comments – (None)

Additional References

NUTRIENTS

Definition of the Attribute

Eutrophication is a term meaning enrichment of waters by nutrients through either man-made or natural means. Present knowledge indicates that fertilizing elements most responsible for eutrophication are phosphorus and nitrogen. Inorganic carbon, iron, and certain trace elements are also important. Eutrophication results in an increase in algae and weed nuisances and an increase in larvae and adult insects. Dense algae growths may form surface-water scums and algae-littered beaches. Water may become foul smelling when algae cells die, oxygen is used in decomposition, and fish kills result. Filter-clogging problems at municipal water-treatment plants and taste and odor in water supplies may all be due to dense algae population.

Army Activities That Affect the Attribute

Sewage and sewage effluent contain a generous amount of nutrients necessary for eutrophication. Treated or untreated sewage discharged from Army bases will contribute to nutrients in receiving waters. Mining, tunneling, blasting, and quarrying into phosphate rocks may cause increased phosphorus from surface runoff. Dredging of waterways will release the storehouse of nutrients contained within the mud bottom; as a result the water will become enriched during and soon after the dredging operation. Many other activities may also enrich the natural waters. These include drainage from cultivated agricultural lands, surface irrigation returns, dead tree and leaves, logging and sawmilling, and dead organisms.

Source of Effects

Nutrients released from many Army activities (described above) will cause

- Aquatic plant problems turbidity, taste, and odor
- Reservoir and other standing waters to collect nutrients and store a portion of these within consolidated sediments (Once nutrients are combined within the ecosystem of receiving waters, their removal by natural process is very slow.)
- Excessive weed growth to eventually block waterways or turn lakes into swamps.

As a result of nutrients released into natural waters, many water-quality parameters will be affected directly or indirectly. Some of these are turbidity due to excessive algae growth; then when algae cells and other plants die, oxygen is used in decomposition and the DOD level declines causing fish kill; rapid decomposition of dense algae scums gives rise to odors and hydrogen sulfide gas that create strong citizen disapproval; and color, taste, and odor cause serious water-treatment problems.

Variables to be Measured and How Variables are Measured

Phosphorus, nitrogen, carbon, iron, and trace metals all act as nutrients. Growth of aquatic plants is governed by the **law of minimum**, i.e., any nutrient out of a broad array of materials required for growth and development governs the growth if it is present in a limiting concentration. Most commonly, in natural waters, phosphorus is present in limiting amounts and governs the normal plant growth.

Phosphorus occurs in natural waters and in wastewaters almost solely in the form of phosphates. These forms are commonly classified into orthophosphates, condensed phosphates (pyro-, meta-, and polyphosphates), and organically bound phosphates. These phosphates may occur in the soluble form, in particles of detritus, or in the bodies of aquatic organisms. Because the ratio of total phosphorus to that form of phosphorus readily available for plant growth is constantly changing and ranges from 2 to 17 times or greater, it is desirable to establish limits in the total phosphorus rather than the portion that may be available for immediate plant use.

Phosphate analysis embodies two general procedural steps: (a) conversion of the phosphorus form of interest to soluble orthophosphate, and (b) colorimetric determination of soluble orthophosphates. The result may be expressed as mg/l P (phosphorus).

Evaluation and Interpretation of Data

Although the concentration of inorganic phosphorus that will produce problems varies with the nature of the aquatic environment and the levels of other nutrients, most relatively uncontaminated lake districts are known to have surface waters that contain 0.001 to 0.003 mg/l total phosphorus as P. (They are nutrient deficient.) Above 0.02 mg/l P, one gets into a region of potential algae bloom. Above 0.1 mg/l P, water is excessively enriched. Table A-4 categorizes five classes of waters based upon total P contact.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

Once nutrients are combined within the ecosystem of the receiving waters, their removal is tedious and expensive. In a lake, reservoir, or pond, phosphorus is removed naturally only by overflow, by insects that hatch and fly out of drainage basins, by harvesting a crop, such as fish, and by combination with consolidated bottom sediments.

The most desirable method to mitigate impact is to treat wastewater as a desired phosphorus level before discharge into the environment. Also, all activities mentioned above should be performed under controlled conditions.

Other Comments – (None)

Additional References

TOXIC COMPOUNDS

Definition of the Attribute

Wastes containing concentrations of heavy metals (mercury, copper, silver, lead, nickel, cobalt, arsenic, cadmium, chromium, etc.), either individually or in combination, may be toxic to aquatic organisms and, thus, have a severe impact on the water community. Other toxic substances include pesticides, ammonia-ammonium compounds, cyanides, sulfides, fluorides, and petrochemical wastes. A severely toxic substance will eliminate aquatic biota until dilution, dissipation, or volatilization reduces concentration below the toxic threshold. Less generally, toxic materials will reduce the aquatic biota, except those species that are able to tolerate the observed concentration of the toxicant. Because toxic materials offer no increased food supply, such as discussed for organic wastes, there is no sharp increase in the population of those organisms that may tolerate a specific concentration.

Army Activities That Affect the Attribute

Many Army activities may contribute to release of toxic compounds into the environment. These include waste discharged from maintenance and repair shops, and from industrial operations. Wastes that are particularly likely to contain toxic compounds result from electroplating, galvanizing, metal finishing, and cooling tower blow down. Other Army activities which may contribute to toxic chemicals are mining, accidental spills of chemicals, chemical warfare, and leaching of landfills containing toxic compounds.

Source of Effects

Chemicals released into the environment may affect surface-water or groundwater systems. It may happen due to direct discharge of wastes containing toxic compounds or from surface runoff which may come in contact with toxic material left as residue over the ground surface.

Variables to be Measured and How Variables are Measured

The spectrum of toxic materials is extremely large and highly diverse in terms of effects. Measurement may be expressed as mg/l of specific compound under consideration. For a group of toxic compounds, it should be pointed out that possible synergistic or antagonistic interactions between mixed compounds may cause different effects than those associated with the respective toxic compounds considered separately.

Bioassay is an important tool in the investigation of these wastes, because results from such a study indicate the degree of hazard to aquatic life of particular discharges; interpretations and recommendations can be made from these studies concerning the level of discharge that can be tolerated by the receiving aquatic community.

The basic bioassay test shall consist of a 96-hour exposure of an appropriate organism, in numbers adequate to assure statistical validity, to an array of concentrations of the substance, or mixture of substances, that will reveal the level of pollution that will cause (1) irreversible damage to 50 percent of the test organisms and (2) the maximum concentration causing no apparent effect on the test organisms in 96 hours.

Evaluation and Interpretation of Data

The bioassay tests may indicate the concentration at which toxic compounds will not cause an apparent effect upon the test organism. However, long-term effects of toxic compounds having more subtle changes such as reduced growth, lowered fertility, altered physiology, and induced abnormal behavior patterns may have more disasterous effects on the continued existence of a species. Also, the biological magnification and storage of toxic residue of polluting substances and microorganisms may have another serious aftereffect. For all these reasons, and as a practical matter, toxic compounds, if they could be detected in natural waters by modern water-quality analysis methods, may render water undesirable for propagation of healthy aquatic life. The five classes of water based upon toxic compounds are given in Table A-4.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

All wastes containing toxic chemicals should be monitored and controlled. Those released into sanitary sewers should be carefully regulated so that such release does not affect the treatment process. Also, after dilution, effluent concentration should not exceed the desired level. Runoffs from chemical handling areas should also be considered to the extent that pollution is expected. If necessary, suitable treatment may be given to all contaminated runoffs.

Other Comments – (None)

Additional References

AQUATIC LIFE

Definition of the Attribute

Organisms in any community exist in a dynamic state of balance, in which the population of each species is constantly striving to increase. However, population is maintained at a fluctuating level determined by food supply, predator, chemical characteristics of water, and physical factors. Since these factors vary greatly, several types of communities exist in balance. Any man-made pollution tends to upset the natural state of balance. This may cause abundance of a few types of organisms while others may decline or completely disappear. Because of some variation in response among species to conditions of existence within the environment, and because of inherent difficulties in aquatic invertebrate taxonomy, ecological evaluation of the total organism community is the acceptable approach, in water-pollution-control investigation. Today's investigators tend to place organisms in broad groups according to the general group response to pollutants in the environment.

Army Activities That Affect the Attribute

All Army activities discussed above (with various water attributes) affect aquatic aquatic life to some degree. Change in an aquatic community depends upon the type and extent of pollution.

Source of Effects

Discharge of organic wastes (sewage) tends to lower the natural DO and to eliminate DO sensitive organisms. Thermal discharge affects the normal life cycle of many organisms. Toxic wastes will reduce the aquatic biota, except those species that are able to tolerate the observed concentration of the toxicant. In general, changes in any attributes whether they are physical or chemical, will influence the aquatic life.

Variables to be Measured and How Variables are Measured

For aquatic life interpretation, field observations are indispensable. However, many of the biological parameters cannot be evaluated directly in the field. The specific nature of a problem and the reasons for

collecting samples will dictate those aquatic communities of organisms to be examined and those, in turn, will establish sampling and analytical techniques. The following communities and types of organisms are considered: plankton, periphyton, macroinvertebrates, macrophytes, and fish. Sampling and identification techniques are based upon routine biological sampling and analysis methods. Readers are referred to *Standard Methods for the Examination of Water and Wastewater*, 13th Edition, 1971.

Evaluation and Interpretation of Data

Based upon most common aquatic life in natural waters, five classes of water are given in Table A-4.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact

See all water-quality attributes for mitigation of impact upon aquatic life.

Other Comments – (None)

Additional References

FECAL COLIFORMS

Definition of the Attribute

Water acts as a vehicle for the spread of disease. All sewage-contaminated waters must be presumed potentially dangerous. The presence of coliform organisms in water is regarded as evidence of fecal contamination since they have their origin in the intestinal tract of humans and other warm-blooded animals. They are also found in soil and water which has been subjected to pollution by dust, insects, birds, and small and large animals. The necessity of coliform tests in water supply has declined somewhat since water treatment plants effectively remove most of the bacteria by treatment and disinfection. However, the test continues to retain importance because of water-contact recreational usage of water, and of implications that viral diseases can be transmitted through fecal contamination of water supplies. Indirect routes such as the contamination of foods with fecally contaminated irrigation water and accumulation of contaminants by oysters, clams, and mussels from fecally contaminated marine waters continue to be areas of concern.

Army Activities That Affect the Attribute

The Army activities discussed in BOD and DO also apply to this attribute.

Source of Effects – (See BOD and DO attributes)

Variables to be Measured and How Variables are Measured

Two methods are used for determining the presence of coliform organisms: the multiple-tube fermentation technique and the membrane-filter technique. The results of multiple-tube fermentation techniques are expressed as Most Probable Number (MPN) based upon certain probability formula. The results of membrane-filter tests are obtained by actual count of coliform colonies developed over membrane filter. In both cases, the estimated coliform density is reported in terms of coliform per 100 ml. The equipment used are the type commonly needed in routine microbiological study.

Evaluation and Interpretation of Data

Present water-quality criteria restrict the use of water depending upon fecal coliform density. The desirable criteria for surface-water supply is fecal coliform less than 20 per 100 ml, and for recreational use (including primary contact recreation) the recommended value is 200 per 100 ml. Based upon the coliform density, five classes of water are summarized in Table A-4.

Special Conditions – (None)

Geographical and Temporal Limitations – (None)

Mitigation of Impact – (See attributes BOD and DOD)

Other Comments – (None)

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As with all other resources available to man, land is not available in unlimited quantities. Because of this, it is becoming increasingly recognized in this country and in other countries with less of an endowment of land resources, that land use must be moderate. CEQ guidelines recognize this need for the rational management of land resources and, because the price system does not allow rational allocation of land, CEQ has provided for a specific consideration of the relationship of a changed pattern in land use to the existing pattern. Therefore, land is being treated much in the same manner as our other scarce natural resources, air and water.

The role of the Army in this endeavor is to insure that land used for maintenance of our military capability does not result in a squandering of this scarce resource. In addition, it is equally important that all possible effort be devoted to undertaking Army activities so that Army uses do not result in serious conflicts with existing nonmilitary land-use patterns.

To consider these factors requires comprehensive consideration of existing and projected land capabilities and land-use patterns. The most significant element of the land-use question for the Army has been collapsed into three attributes:

- Erosion
- Natural hazards
- Land-use patterns.

EROSION

Definition of the Attribute

Erosion is defined as the process through which soil particles are dislodged and transported to other locations by the actions of water and/or wind. The two most common forms attributable to water are sheet erosion in which the upper surface of the soil is more or less evenly displaced, and gully or rill erosion in which the downward cutting action of the overland flow of water results in linear excavations deep into the soil horizon. While the latter type of erosion is often more spectacular to the eye, loss of uniform layers of topsoil through sheet erosion is the more serious of the two. Wind erosion is similar to sheet erosion in that very small soil particles containing plant nutrients and organic matter are the ones that are carried away, leaving coarse and less productive material.

Soils of almost all types are held in place on slopes by vegetative cover and its associated root system. Removal of this cover exposes the soil to the erosive forces of water and wind. Erosion is intensely destructive. First, the site itself may be denuded of its most productive topsoils and/or may be gullied to the extent that it becomes almost totally unproductive, often to the point of posing a physical barrier to other activities. Second, the streams and lakes which receive the attendant sediment loads may be affected. The landscape after erosive forces have been at work is barren and aesthetically unappealing.

Army Activities That Affect the Attribute

Army activities that affect the extent and rate of erosion are those associated in any way with removal or reestablishment of vegetative cover. Some of these are land clearing for construction, road building or other cut and fill operations, timber harvesting or vegetative suppression by herbicide application, controlled burning, reforestation or afforestation, mechanized training, mission change or base closing, and large-animal grazing.

Source of Effects

Land-clearing and mechanized-training activities strip land of its vegetative cover, organic surface material, and root structures which formerly protected the soil, thereby opening it up to direct attack by wind and water. Timber harvesting, application of herbicides, and controlled burning can result in the removal of a sufficient quantity of organic surface material and vegetative cover to cause an increase in the intensity of rainfall and wind movement at the soil surface. Conversely, reforestation and afforestation can reintroduce a vegetative canopy and root structure which – over time – can reduce the intensity of these erosive forces and result in a buildup of organic surface material. Road building and other cut-and-fill activities lay bare previously vegetated soil, alter natural drainage patterns, change the gradient of slopes, and create somewhat unconsolidated-fill areas upon which vegetative cover is often not immediately reestablished. The stripping away of vegetative shrub and ground cover in semiarid areas by overgrazing is one of the most widespread causes of wind erosion. If grazing rights are not renewed or large wild animals are fenced out of and/or removed from overgrazed areas, seeding to native grasses can accelerate the return of vegetative cover and reduce erosion potential.

Variables to be Measured

Major variables affecting erosion are soil composition or texture, degree of slope, uninterrupted length of slope, nature and extent of vegetative cover, and intensity and frequency of exposure to the eroding forces. The interaction of these variables is complex and difficult to measure directly. Magnitude of the impact is also directly dependent on the extent of the affected area.

Soil texture is determined by the percentage of its sand, silt, and clay components. Generally accepted textural classes in order of decreasing particle size (coarse to fine) are:

Sand	Silt loam	Silty clay loam
Loamy sand	Silt	Sandy clay
Sandy loam	Sandy clay loam	Silty clay
Loam	Clay loam	Clay.

While such a statement is subject to contradiction on a specific site, finer textured soils are usually more susceptible to water erosion. Sandy soils and granulated clays are those most easily eroded by wind.

Erosion increases with the length and steepness of slope. A general rule is that if the length of slope is doubled, soil loss from erosion will increase by a factor of 1.5. The relationship between degree of slope (gradient)* and erosion potential can be specified in general terms as follows:

10 percent $\geqslant$ highly erodible
2-10 percent = moderately erodible
2 percent $\leqslant$ slightly erodible.[1]

The erosion hazard depends upon the intensity and frequency of rain and wind storms. While the amount of yearly rainfall is important, of greater significance is the force with which it strikes the ground, volume in a given time, and return frequency of intense storms. The impact of wind varies with velocity, direction, and soil-moisture content.

The differences in types of vegetative cover and the extent of each also affect erosion potential. A mature forest with a heavy overstory (leaf or needle) cover, an understory of trees with less dense leaves, scattered ground vegetation, and a heavy layer of decaying organic matter will protect the soil from wind and water to a greater extent than will be brush and sparse ground cover found in arid and semiarid areas. These are extremes – pasture and cultivated cropland fall somewhere between.

Before proceeding further, some informed judgment should be made as to whether these variables are operative to a degree and in sufficient combination to warrant the rather extensive calculations to be described next. If necessary, an agronomist or agricultural engineer from the local office of the U.S. Soil Conservation Service (SCS) could assist in making this initial assessment.

*(Slope gradient is the relationship between the vertical height and the horizontal length of the slope).

How Variables are Measured

Most soil-loss or -erosion equations are based upon models that represent interrelationships among the variables just discussed. One such model developed for agricultural cropland – but subject to modification for other vegetative types is:[2]

$$A = RKLSCP$$

where,

A = Computed soil loss per unit area (acre)
R = Rainfall factor
K = Soil-erodibility factor
L = Slope-length factor
S = Slope-gradient factor
C = Crop-management factor
P = Erosion-control-practice factor.

While the techniques of arriving at numbers to represent the various factors are adequately described in the handbook which should be available from the local office of the Soil Conservation Service (SCS), it would be helpful to have the expert advice of a team of SCS agronomists, hydrologists, and agricultural engineers in applying it to a specific site. Soil loss should be computed both with and without the project.

The area affected should be outlined on a map overlay of appropriate scale; through the use of a planimeter and with the assistance of an engineer, the number of acres affected can be determined. Total soil loss with and without the project can then be calculated by multiplying the soil loss per acre, as previously obtained from the model, by the number of acres involved. This change, expressed as a percentage, can be obtained from the following equation:

$$\text{Percent change in soil loss} = 100 - \left(\frac{\text{Soil loss without project}}{\text{Soil loss with project}} \times 100\right)$$

Evaluation and Interpretation of Data

Overall magnitude of the impact can be represented by the percent change in total soil loss as calculated above. If a more sophisticated analysis appears to be warranted, this quantitative figure can be tempered by a further evaluation that takes into account change in soil fertility (productive capacity) and the impact of changes in sediment load in streams that drain the affected area. This kind of analysis could best be done by an interdisciplinary team of economists, agronomists, engineers, and ecologists.

Special Conditions

If the land was productive for agricultural crops or forest products, the economic and ecological impacts of might be greater than if it were relatively infertile.

Geographical and Temporal Limitations

While there are few areas in the United States where the potential for at least moderate erosion does not exist, most severe erosion has occurred in the Appalachian area of the Southeast, in the Great Plains, and in some desert and semiarid areas of the Southwest. The major temporal limitation on erosion involves the time of year when the soil is exposed and the length of time it remains exposed relative to the time of year that intense rain and windstorms are likely to occur.

Mitigation of Impact

It is much easier to prevent erosion before it begins than it is to arrest or restore the land afterwards. The environmental impact of soil erosion can best be mitigated by removing vegetative cover only from the specific site on which construction is to take place and by disturbing the vegetation in adjacent areas as little as possible. Construction, land management, or training activities that result in the soil being laid bare could be scheduled in such a way that some type of vegetative cover appropriate to the site could be established prior to the onset of intense rain or windstorms. If grass is to be seeded, a mulch of straw will help to protect the soil from less extreme erosive forces until vegetative and root development begin. Natural drainage patterns can often be maintained by preparing sodded waterways or installing culverts. Steep slopes can be terraced, thereby effectively reducing the length of slope. Catch basins built near construction sites can reduce the quantity of eroded soil particles reaching free-flowing streams or lakes. Additional information on mitigation techniques is available in a U.S. Environmental Protection Agency report.[3]

Other Comments

If the erosive effects resulting from an activity are not confined to the Army installation but spill over into adjacent private lands (sediment deposition), or if severely eroded land is visible from public highways, after-the-fact controversy over the project may develop. This is especially true if these considerations are not directly addressed in the environmental assessment/impact statement and the mitigation possibilities not discussed and evaluated.

Additional References

NATURAL HAZARDS

Definition of the Attribute

Natural hazards are those occurrences brought about by the forces of nature that cause discomfort, injury, or death to man; damage or destroy physical structures and other real or personal property; change the physical character of land, water, and air; and damage or destroy the plant and animal life of the affected area. The severity and frequency of occurrence of floods, earthslides, and wildfires may be influenced by Army activities. Other natural hazards such as earthquakes and hurricanes may cause greater personal and physical damage than would be the case if Army activities were located in areas other than those where these events occur with predictable frequency and severity.

Army Activities That Affect the Attribute

Some Army activities that often have an impact on the frequency and magnitude of natural hazards are construction, land management, land use, mission change, and training. These activities do not affect the natural processes that are the root causes of hazards – intense rain or wind storms, the geologic structure and soil and bedrock properties of an area, or lightning strikes from thunderstorms. Rather, it is the destructive nature of the results of these occurrences that Army activities influence.

Source of Effects

The effects of Army construction activities on the destructive potential of natural hazards are quite diverse. Land clearing which precedes most kinds of construction lays bare the soil surface, a condition conducive to increased volumes of water runoff and increased sediment loads in streams – both of which tend to cause increases in flood heights and return frequencies, the two greatest determinants of flood damage. (Building structures such as dams and levies and stream channelization to reduce flood levels fall largely within the Civil Works area of the Corps of Engineers, and their effects are not discussed here.) Paving large areas with asphalt and concrete – often done for vehicle parks and outdoor storage areas – reduces infiltration of water into the soil, thereby increasing runoff and the peak volume water streams are required to carry.

The probable incidence of earthslides may be increased by road-construction activities if natural shear stresses in the earth are increased, excessive pore pressure developed, or rock and soil strata exposed by road cuts. Failure may be induced by blasting, changes in slope, greater overburden, etc. Earthslides can block streams and cause a back up of water which in turn can result in upstream damage due to a gradual rise in water level and extensive downstream damage due to the rapid release of water when the slide is overtopped or eaten away. Earthslides also destroy vegetation, increase sediment loads in streams, and disrupt transportation routes. On the positive side, road construction in remote areas can reduce potential wildfire damage by permitting more rapid access by firefighting crews and equipment.

Land management includes activities such as timber harvest, reforestation and afforestation, herbicide application, and controlled burning. Timber harvest can create at least temporary increases in runoff volume and sediment loads as a result of the removal of some of the vegetation cover and the disturbance of the soil surface by trucks and other mechanized equipment. Rehabilitation of eroded areas by reforestation, afforestation, or seeding decreases runoff and sediment loads. Timber harvest on steep slopes can result in landslides which disturb the soil horizon to the extent that natural tree regeneration will not take place. When vegetation killed by herbicides and logging debris left after timber-harvest operations dry to the point where the plant material will ignite easily and burn with considerable intensity, lightning strikes are more likely to cause fires that are difficult to control and may do great damage. Conversely, controlled burning can reduce the incidence and destructive potential by wildfire by creating a low-temperature blaze that consumes the dry underbrush and organic matter on the forest floor without damaging mature timber. (This favorable impact of controlled burning should not overshadow the fact that it may adversely affect other environmental attributes such as vegetative diversity, wildlife populations, and erosion.)

Land-use considerations that dictate where certain projects will be located often have a decided impact on natural hazards. Any physical structure (building, bridge pier, and temporary bridge) that occupies a portion of the floodway (the stream channel that carries the normal water flow) or is situated on the floodplain (that area covered by flood waters when a stream overflows its banks) will restrict the flow of water and decrease the volume which the floodplain can accommodate at a particular level, thereby increasing flood heights both upstream and downstream. Permitting mobile homes or other portable structures to be located in floodplains poses the possibility of increased physical damage to the structures and loss of life to their occupants. During a flood, they can damage other structures by direct impact or lodge in the stream channel in such a way as to form a temporary dam, raising flood levels behind them. Siting military housing in areas of brush or forest land subject to wildfire can increase the damage potential to life and property. The same is essentially true of any structures placed near known fault lines in active earthquake zones or in coastal or inland river areas subject to frequent wind and water damage from hurricanes. Abandonment of these danger areas as a result of mission change (relocation of facilities) or base closings can reduce the hazard.

Fire deserves special treatment as it is more often caused by man than nature. No matter what its origin, however, its destructive impact on the environment is the same. For this reason, any Army activity that changes the probable incidence of wildfire should be reviewed. The positive impact of controlled burning has already been noted. Troop-training activities — particularly those in which incendiary munitions are used — carried on in areas where the vegetation will support combustion and the opening up of certain areas of Army reservations to the public for hunting, hiking, or camping may increase the potential incidence of wildfire.

Variables to be Measured

Each type of hazard has its own set of variables that influence frequency of occurrence and severity. For floods, changes in volume of the overland flow of water and in sediment deposits in stream channels or on the floodplain cause variation in flood height and resultant damage levels. Baseline data can sometimes be obtained direct from gauging stations that record the magnitude of the increased stream flow resulting from runoff associated with the storm. Changes in the infiltration rate of water cause changes in the volume of surface runoff from overland flow

and in the amount of sediment carried into the stream. The resulting change in return frequencies of certain levels of flooding is the critical determinant of impact.

Earthslide-prone areas are those characterized by unstable slopes and land surfaces which – because of a history of actual occurrences, geology, bedrock structure, soil, and climate – present a significant hazard potential. The variables here are the extent to which soil and rock strata are exposed to wetting, drying, heating, and cooling processes; the slope gradient of the cut which exposes the relevant stratum; and changes in internal earth stresses caused by surface or subsurface loadings, e.g., blasting, heavy machinery operation, and installation of footings and foundations.

The variables associated with wildfire are changes in flammability of the organic matter on the ground (duff) and the areal extent of the Army activity. Changes in wind velocity near the ground, depth of the duff, and moisture content of the duff influence on its capacity to support combustion and the intensity with which it will burn once ignited. The size of the activity in terms of changes in the volume or area of standing timber, in the number and value of physical facilities, and in the number of people housed or working in areas susceptible to wildfire influences both the probable incidence of wildfire and the magnitude of the resultant damage.

How Variables are Measured

Few if any of the variables associated with baseline data on natural hazards are subject to measurement by the layman. It is even more difficult to project changes in the variables over time as a result of Army activities.

For floods, the assistance of an expert hydrologist is required to relate rainfall intensity (rate over time), infiltration capacity of the soil (the maximum rate at which soil in a given condition can absorb water), overland flow (rainfall excess that reaches stream channels as surface runoff) and its effect on channel depth, and the resulting increase in flow rate over time (hydrograph) which would yield a certain flood height and attendant damage level. The major variable – change in soil infiltration capacity – is influenced by such diverse and interrelated factors as interception of rain by trees and buildings, depth of surface detention of water and thickness of saturated soil layer, soil moisture content, compaction due to machines and animals, microstructure of the soil, vegetative cover at or near the surface, and temperature. No single formula can be used to relate changes in these variables to a specific change in the infiltration capacity of soil without the judgment of a hydrologist familiar with the watershed and area in question.[4] The nearest district office of the Corps of Engineers, Civil Works Division, should be able to assist in obtaining baseline data and in projecting the effects of Army activities on flood heights and return frequencies.

The relative tendency of an area to have earthslides is not subject to simple measurement; the forces which cause an earthslide and the extent of their interactions are extremely complex. To the expert geologist, the type of geologic structure common to the area, the type of bedrock, soil structure, height of water table, type of surface material, degree of natural slope, and past history indicates whether an area is prone to earthslides. Such general information can often be obtained from the U.S. Geological Survey, from state geologists, or from local universities. If the area is prone to earthslides, an engineering analysis should be made to determine whether physical changes that result from the Army activity are likely to increase or decrease the probable incidence with which slides may occur. The services of both a soil and civil engineer would be required for a thorough analysis.

Baseline data on the conditions and occurrence of wildfire should be available directly from the nearest office of the U.S. Forest Service or from the state forester's office. These records usually include or can be correlated with other data relating to the thickness of the duff, the relative humidity, number of days since the last rain, wind velocity, and other local factors which in combination give the fire-danger rating. Local foresters specializing in the calculation of fire-danger ratings could assist in projecting the change that the Army activity would have on the previously identified specific variables, i.e., wind velocity near the ground, depth of duff, and moisture content of the duff. Any change in the area (acres) susceptible to wildfire should also be measured. This can be done with before and after overlays of the area, prepared from maps, aerial photographs, or site plans. Through the use of a planimeter, the size of the

area for each can be determined. The assistance of an engineer may be required to make this calculation.

Evaluation and Interpretation of Data

For flood hazards, the magnitude of the impact of a change in infiltration capacity of the soil and the attendant change in rate of surface runoff on flood stage height and return frequency needs to be evaluated. A more sophisticated analysis could relate the change in flood height and return frequency to potential dollar losses or losses of human life – taking into account existing structures that might be affected as well as any new ones to be located in the floodplain. This latter analysis could probably best be made by insurance underwriters associated with the National Flood Insurers Association or by the Federal Insurance Administration of the U.S. Department of Housing and Urban Development.

Evaluation of changes in potential incidence of earthslides is less straightforward. The areas where earthslides are most likely to occur should be evident from the previously recommended engineering analysis. The impact of a slide in a particular area could be calculated in terms of the dollar value of physical damage to structures, loss of life, and the ecological damage to watercourses and vegetation. Then the no project alternative could be considered – that is areas in which slides are likely to occur even in the absence of Army activity and damages likely to result therefrom. A team of engineers, geologists, and insurance underwriters could develop risk factors associated with changes in the potential incidence of earthslides.

Just as with other natural hazards, wildfire has two aspects to be separately evaluated – the change in potential incidence and the amount of damage that might result from an occurrence. Again, the considerations are complex and not amenable to one-dimensional evaluation and interpretation. The change in incidence is related to change in flammability and areal extent of the duff, to greater or lesser numbers of people in the area, to the nature of the proposed activity, and to measures taken to prevent or reduce wildfire damage. A team of foresters and fire insurance underwriters should be able to develop risk factors associated with the change in potential incidence and intensity of wildfire and then estimate property damage or the loss of life that might result – both with and without the project.

Special Conditions

If increases in flood heights and frequencies are likely to adversely affect floodplains where extensive industrial, commercial, or residential development already exists; if increased incidence of earthslides is likely to damage population areas and/or cause severe ecological damage; or if residential or prime-timber producing areas are subjected to higher risks of damage from wildfire – particularly if any of the effects are felt outside the confines of the Army installation – controversy over the projected magnitude of the impacts is almost certain to develop. In such instances, an interdisciplinary team of qualified professionals is needed to develop and substantiate these projections.

Geographical and Temporal Limitations

Geographic limitations on natural hazards have to do with observed frequencies of occurrence, e.g., hurricanes are most likely to affect Gulf and Atlantic coastal areas; earthslides are unlikely to occur in areas of relatively flat terrain; and earthquakes occur more frequently and with greater severity along known geological fault lines. While floods and wildfire can occur almost anywhere, the frequency and severity of lightning storms in mountain regions of the western states increase the incidence of wildfire in that geographical area. Some general temporal limitations are that wildfire is most likely to occur in the summer and fall when the moisture content of living vegetation and the duff is lowest; floods of greatest severity occur with a certain predictability in the spring, but flash floods can take place at almost any time of the year; the hurricane season is considered to be summer and early fall; and earthslides of various types most often occur in the winter and spring. Temporal limitations do not seem to apply to earthquakes.

Mitigation of Impact

Primary mitigation techniques for hurricanes and earthquakes center around the avoidance of areas where these hazards occur with sufficient frequency and intensity to cause severe damage and the use of proofing techniques in the construction of physical facilities. Proofing techniques include the use of "floating" foundations and height restrictions in earthquake zones and increased foundation height, wall strength, and roof support in areas periodically subject to hurricanes.

The frequency and/or severity of flooding can be held to a minimum by prohibiting any construction activity or land use that restricts the flow of water in natural channels or that reduces the floodplain area that overflow waters during times of flooding. Generally speaking, all forms of temporary structures should be banned from the floodplain and all permanent structures should be raised to a height above the level which flood waters can be expected to reach once every 100 years (100-year flood). No temporary dwelling units – mobile homes and the like – should be permitted in the floodplain.(5) Increases in surface runoff can be mitigated by disturbing the existing vegetation and natural contour of the land as little as possible. Installation of underground drainage structures helps to reduce sediment loads (overland flow is reduced) but not total runoff volume.

Earthslides can be mitigated by avoiding areas with a high probability of incidence or those where proposed activity will significantly increase their probability. Engineering plans can be drawn to reduce the area of exposed strata subject to earthslides, reduce the inclination of slope of earth cuts on fills below what might otherwise be acceptable, provide physical support for exposed soil or rock faces, concentrate or distribute – as appropriate – the weight loadings of foundations to areas or strata better able to support that weight, use small charges for blasting, and restrict the movement of heavy machinery during the construction phase.

The effects of wildfire can be mitigated by clearing fire lanes in strategic locations and building restricted-access roads into areas having a high probability of wildfire incidence. Removal of live vegetative cover that permits the drying forces of wind and sun to interact more directly with the duff should be avoided if possible. In timber-harvest operations, the removal from the woods of as much of the total tree as is commercially possible to use will reduce the amount of vegetative logging debris left to contribute to depth and flammability of the duff. Restrictions on the use of areas during periods of high fire danger and prohibition of the use of incendiary munitions in training activities are examples of other types of mitigation techniques. Also, buildings should be sited (on the prevailing downwind slope) and roads constructed (more than one access and egress point) so as to minimize physical damage and loss of life if a wildfire should occur.

Other Comments

The impact of Army activities in areas subject to natural hazards (hurricanes and earthquakes) has not been treated in detail. The most appropriate measure of impact in such cases is the change in the number of people and in the dollar value of physical facilities exposed to these hazards as a result of closing, expanding, and mission changing an existing facility or opening a new facility.

Additional References

LAND-USE PATTERNS

Definition of the Attribute

Land-use patterns are natural or imposed configurations resulting from spatial arrangement of the different uses to which various plots of ground are put at a particular time. Land-use patterns evolve as a result of (1) changing economic considerations inherent in the concept of highest and best use of land, (2) imposing legal restrictions (zoning) on the uses of land, and (3) changing (zoning variances) existing legal restrictions.

The critical consideration here is the extent to which any changes in land-use patterns resulting from Army activities are compatible with existing adjacent uses and in conformity with approved or proposed land-use plans. The most recent guidelines on the content of environmental impact statements indicate that "where a conflict or inconsistency exists (between a proposed action and the objectives and specific terms of an approved or proposed Federal, state, or local land-use plan, policy, or control), the statement should describe the extent to which the agency (the Army) has reconciled its proposed action with the plan, policy, or control, and the reasons why the agency has decided to proceed notwithstanding the absence of full reconciliation".(6)

Army Activities That Affect the Attribute

Changes in mission or changes in the working or resident populations at an Army facility are activities most likely to induce changes in the pattern of land use and create compatibility problems with adjacent uses. The building of new or the expansion of existing installations through a program of land acquisition would be the Army activity most likely to result in a conflict with approved or proposed Federal, state, regional, or local land-use plans. If such a conflict exists, it is quite possible that a compatibility problem with adjacent uses will also emerge.

Source of Effects

In terms of changes in land-use compatibility patterns, increased or decreased noise levels from a mission change could have a decided impact. If a large supply or maintenance depot is established at a post that was previously administrative headquarters, the attendant increase in rail and truck traffic, particularly if routed near or through residential areas adjoining the base, could result in increased noise levels that might be incompatible with the existing use. Even greater noise problems affecting land-use compatibility patterns might arise if an airstrip had to be constructed on the post or an existing one expanded or used more intensively to facilitate the movement of time-sensitive supply items. On the other hand, if an air-to-ground gunnery range for helicopter gunships was permanently closed and the property disposed of as a result of force reductions, a greater variety of adjacent land uses might become compatible with it due to the reduction in noise levels and in the hazard from stray munitions.

Installation closings resulting in the working and resident populations of a post being reduced almost to zero would usually have a decided impact on the land-use patterns of nearby private property. These changes might not be easily perceived at first. Residential and commercial areas would remain, but their intensity of use would probably be sharply curtailed. Portions of such areas might eventually revert to a lower use — the structures possibly being razed and the land permitted to return to open space or some nonintensive form of agriculture. The issue of compatibility with adjacent uses might arise if the use revision took place in a random and essentially uncontrolled fashion.

Large increases in the number of civilians or military personnel working at an Army facility would almost certainly have repercussions on land-use patterns in the area. An example would be the introduction into areas near the post of residential structures that are basically unsuited for such development. Mobile-home parks or high-density apartment complexes might be sited adjacent to the approach pattern of aircraft runways on what was previously agricultural land. This could come about if variance to zoning ordinances was granted by some local governments in an attempt to encourage population growth in their political jurisdictions.

Activities involving land acquisition will conform or conflict with approved or proposed Federal, state, regional, and local land-use plans in relation to whether such plans exist at all, their detail, and the specific use of the acquired land. For example, if the

Army purchased land for the construction of an office building in an area specifically designated for residential use by an approved zoning ordinance, there would be a direct conflict with a land-use plan. Conversely, if the land were purchased as a site for the construction of family housing units, there would be no apparent conflict. These considerations were reflected in the decision rendered by the U.S. Court of Appeals of the District of Columbia in the case of Maryland Planning Commission v. Postal Service, August, 1973.

Army activities which influence changes in land-use patterns certainly do not always do so adversely. There may be compatibility conflicts in the existing land-use pattern which would be ameliorated by Army activities. An influx of people (with an appreciation of planning) into an area having no comprehensive zoning ordinances or land-use plans could result in the formulation and adoption of such ordinances or plans. Over time, this could result in more compatible land uses in the area surrounding the Army facility.

Variables to be Measured

Compatibility of use between one parcel of land and adjacent properties involves variables such as type and intensity of use (residential, commercial, industrial, transportation, agricultural, mineral extraction, and recreational, and subbreakdowns within each that reflects use intensity), population density, noise, transportation patterns, prevailing wind direction, buffer zones, and aesthetics. For example, a high level of residential/transportation land-use compatibility would be evident where a single family home is set back 30 feet from a two-lane street having a traffic volume of 20 cars per hour which travel at an average speed of 25 miles per hour. Conversely, considerable incompatibility would exist if the same house is set back the same distance – with no intervening barriers – from a four-lane highway with a traffic volume of 2000 vehicles per hour, the majority of which travel at 70 miles per hour.

Conformity of a proposed new use of land with approved or existing land-use plans is determined by whether a plan exists for the area in question and if so, whether the proposed use conforms with the ones permitted in the plan. This is a very straightforward relationship unless attempts are made to correlate use/plan conflicts with variances under which precedents for change may have been set.

How Variables are Measured

Because the constraints that influence compatibility vary widely with the types of land use involved and the spatial arrangement of one with another, variables (such as traffic flow, population density, noise levels, depth/width/area of buffer zones, and constituents and quantity thereof in air/water/solid effluents) are subject to physical measurements by engineering and planning professionals. Even aesthetic qualities are subject to a somewhat objective measurement by landscape architects. With respect to compatibility of use, however, measurement alone does not indicate the magnitude of the impact. It is the relationship of these variables to one another in the context of their specific spatial arrangement that determines compatibility.

Measurement of variables reflecting conformity with a land-use plan is essentially a yes-no proposition. A plan with which the proposed use can be compared either exists or does not. If a plan exists, the proposed use either conforms or conflicts with its provisions. In practice, the assistance of a spatial planner/zoning expert would probably be required if the proposed use is complex or if the plan is couched in legal terminology. Land-use plans may be prepared at all levels of local government – incorporated towns and municipalities, townships, and counties; by regional planning agencies (for agencies in specific areas refer to *Regional Councils Directory* published periodically by the National Association of Regional Councils); by state departments of planning, development, and natural resources (for specific state-by-state information refer to *A Summary of State Land Use Controls* published by Land Use Planning Reports, September, 1973); and by Federal land-management agencies such as the Bureau of Land Management, the National Park Service, the Bureau of Indian Affairs, the Bureau of Sport Fisheries and Wildlife, the Bureau of Reclamation, The Corps of Engineers (Civil Works Division), the Tennessee Valley Authority, and the Atomic Energy Commission.

Evaluation and Interpretation of Data

Discussion of the variables involved in land-use compatibility attempts to convey the idea that there is no simple way to relate these variables and arrive at a compatibility index. While planning standards exist, the way in which they are applied in practice varies considerably from one political entity to another, from one geographic area to another, and with the types of existing and proposed uses. The assistance of a city and regional planner with a background in the spatial arrangement of land uses would be essential in measuring and analyzing interactions among variables and, subsequently, in interpreting the results in terms of the relative compatibility of the uses.

For reasons of continuity, evaluation and interpretation of whether a proposed Army use of certain parcels of land conforms or conflicts with existing or proposed land-use plans was included in the previous discussion on the measurement of variables.

Geographical and Temporal Limitations

There appear to be no geographic limitations directly influencing the compatibility of adjacent uses of land. On the other hand, geographic boundaries of political entities govern the areal extent of the particular land-use plans which the Army activity may impact.

Temporal considerations relate to the problem of projecting how land-use patterns are likely to evolve as a result of a proposed Army activity. The period of analysis usually used is the expected beneficial life span of the project.

Mitigation of Impact

Compatibility between adjacent land uses can best be assured by providing an open-space buffer zone between the proposed Army activity and nearby civilian properties where any significant degree of incompatibility is likely to result. The width/depth/area of this buffer zone should not be excessive since to make it so could be construed as an inefficient use of land. As for mitigating the impact of changes in existing uses among adjacent off-post parcels of land likely to evolve as a result of the proposed Army activity, officials of affected local political entities and regional, state, and Federal agencies could be apprised at an appropriate time of the projected impacts. They would then have the opportunity to change existing or enact new land-use plans.

Mitigation of conflicts between a proposed Army use of land and proposed existing land-use plans can be best accomplished during the planning stage. Obviously, it would be most desirable from an environmental standpoint to locate the activity where no conflict in use would exist. If this is not feasible, discussions could be held with representatives responsible for the plans with a view toward resolving the conflict through the granting of a zoning variance or plan modification. Even if no satisfactory agreement can be reached, the fact that such discussions were initiated and conducted in good faith by the Army might have a positive impact on any future controversy or litigation.

Other Comments

On the surface, it would appear that **proposed** land-use plans, policies, or controls as well as those which **generally** address land use **without** supportive legal instruments (ordinances, laws, administrative rules) would not be as binding — or taken into account to the same degree — as would those **specifically** and **carefully** drawn, **officially** enacted or promulgated, and having the **support** of legal precedent. However, the language of the previously quoted CEQ guidelines is rather unequivocable. For an impact assessment/statement, no differentiation is made between approved and proposed plans, policies, and controls. Time and precedent will determine how this element of the guidelines is interpreted in practice.

Additional References

REFERENCES

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(3) *Control of Erosion and Sediment Deposition from Construction of Highways and Land Development*, U.S. Environmental Protection Agency.

(4) Brater, E. P., and Wisler, C. O., *Hydrology*, Second Edition, John Wiley and Sons, Inc. (1959).

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ECOLOGY

The characteristics of man's environment are intimately related to the nonhuman ecology that surrounds him. Problems that affect lower level elements in the ecological system may ultimately affect man itself. For example, the accumulation of pesticides and heavy metals in lower levels of the ecologyical system may be harbingers of dangerous levels of these materials in man.

In addition, despite progress that man has made in providing for his needs, the total ecological balance of the environment is crucial to the viability of man. For this reason, species diversity and balance must be maintained. Convincing evidence exists that species diversity in an ecosystem is closely related to the stability of that system, with increasing species diversity indicating an increased ability of the ecosystem to resist disturbance and stress. Evaluation of impacts on a given ecological system should include an assessment of the effect of proposed alterations of the environment on species diversity – based on existing information or on special field studies.

The attributes that have been identified to describe the "ecology" resource are

- Large Animals
- Predatory Birds
- Small Game
- Fish, Shellfish, and Waterfowl
- Field Crops
- Threatened Species
- Natural Land Vegetation
- Aquatic Plants.

LARGE ANIMALS (WILD AND DOMESTIC)

Definition of the Attribute

Large animals are those, both wild and domestic, that weigh more than 30 pounds when fully grown. Common wild animals falling into this category are deer, bear, elk, and moose. Domesticated animals of this size include horses, sheep, cattle, swine, and goats.

Army Activities That Affect the Attribute

Since most large animals (except for some which are quite rare, i.e., cougars, wolves, etc.) are browsers or grazers, Army activities having the greatest effect upon them are those which diminish the animals' vegetative food supply or otherwise make inhospitable to them all or portions of the area over which they range. Examples of such activities are construction of new facilities (roads, vehicle and ordnance test areas, and buildings) or the abandonment of old ones, field training, establishment of artillery or helicopter gunship firing ranges, and security fencing.

Source of Effects

Vegetative and other forms of cover – for traveling, eating and watering, sleeping, breeding, and rearing of young – are required by all wild animals if they are to thrive in an area. Construction activities which result in the clearing of underbrush by burning or other physical means can reduce the available range over which large animals forage. Likewise, application of herbicides can reduce both cover and food, unless utilized in programs specifically designed to increase cover and food. Acquisition of new land for Army activities, if such land was previously used for the grazing of domestic livestock, can reduce the total area available for that purpose in a particular locality. Noise can cause large wild animals to leave or avoid a particular area. Security fencing can restrict the movement of animals, either denying them access to food and water areas or keeping them penned within an area smaller than that required for their well-being.

Variables to be Measured

The most direct variable is animal population. The type (species) and number of large animals should be determined. To arrive at the magnitude of the impact on the population, the change in the amount (acres) of land suitable for large animal habitat must be determined. A relative measure of the increased noise generated by man's extensive intrusion into wild, remote areas where he formerly ventured only as a hunter or herdsman should be made. Intense and prolonged noise-generating activity can sufficiently change the habits of large animals to cause them to vacate an area – at least temporarily – until man's activities are reduced or the animals become accustomed to them. Adjacent areas can be stressed by having to temporarily support greater populations.

How Variables are Measured

A census of large-animal populations can be made by direct observation. If small, the entire area can be censused. If large, counts can be taken on random plots and projected over the total area of suitable habitat. Good observational and outdoor skills are required for many direct counts. In some areas of fairly open terrain, skilled photointerpreters can taken the census of large animals from aerial photographs. If direct observation is not practical or possible (lack of skilled people, large area, nature of the habitat or animal species), a local wildlife biologist affiliated with a Federal or state wildlife agency should be consulted for his estimate of the population (numbers of domestic animals should be available from ranchers using the land). Wildlife specialists are professionally qualified to judge how noise and other nondestructive activities of man and vehicles affect the use of an area by large animals.

The change in acreage of a particular habitat type can be obtained from before and after overlays prepared from aerial photographic prints, project plans, or maps. Through the use of a planimeter, the size of these areas can be determined with the assistance of an engineer or surveyor. While a direct proportion can be made between the large-animal population and acres of available habitat, it would be helpful to have a wildlife biologist review the calculations and determine the relative quality of the seasonal variations, etc. The following equation reflects the previously mentioned population/habitat area relationship:

$$\text{Future Population} = \frac{\text{Present Population} \times \text{Future Habitat Acreage}}{\text{Present Habitat Acreage}}$$

Evaluation and Interpretation of Data

The increase or decrease of the large-domestic-animal population of an area can be interpreted on the basis of the resulting change in annual income. A more subjective evaluation must be made for wild animals. The number lost or gained relative to the number originally in the area is the most critical element. If any of these wild animals prey on smaller animals, the effect of the increase or decrease in that population should be considered. Not to be overlooked are the aesthetic value of large wild animals and the economic dividends which accrue to an entire region if the animals are subject to hunting. Neither of these two values can be readily quantified, and any judgment of their significance must remain highly subjective.

Special Conditions

If there is a long tradition of grazing rights for domestic livestock and these rights are to be withdrawn, the impact of the activity could become controversial – particularly if these rights had previously been exercised by Indians. If any of the wild animals are considered to be threatened (formerly categorized as rare or endangered) – regionally, nationally, or internationally – a reduction in their numbers as a result of the Army activity, particularly habitat alteration, would likely result in controversy. (The attribute write-up covering threatened species goes into greater detail on this subject.)

Geographical and Temporal Limitations

Concern about domestic animals and associated grazing rights is of significance primarily in the Western United States where rights to use Federal lands for this purpose still exist. As already noted, the impact of a particular Army activity on wild animals may be short-term, occurring only during the construction or direct activity period when men and equipment intrude most heavily on the animal's home

range. Also, in alpine and high-plains areas, large animals have both a summer and winter range. factor in determining their presence in or absence from an area. The impact of the reduction in summer range would likely not be as severe, for example, as would be a reduction in winter range.

Mitigation of Impact

The impact of Army activities on large animals can best be mitigated by intruding as little as possible on their habitat. If such animals use the area where the activity will take place, it should be concentrated to the maximum extent possible in those parts of the area which they least often frequent. During the planning phase of an activity, an attempt should be made to avoid extending into the home range of large wild animals. If this is not feasible, the activity should be completed as quickly as possible, and regular and sustained use of the area over time should be minimized. If land acquisition is necessary and a choice is possible, a productive range used by large domestic and/or wild animals should be avoided.

Other Comments

If the Army activity impinges upon the range of large wild animals that have previously been hunted in the particular area and if the activity will result either in closing that area to hunting or a reduction in the number of such animals available for annual harvest, sportsmen's clubs are likely to oppose the activity. Economic interests may also object strenuously if significant profits are derived from hunting-related businesses.

Additional References

PREDATORY BIRDS

Definition of the Attribute

Birds of prey are flesh eaters and obtain their food primarily by hunting, killing, and eating small animals, other birds, and fish. Common birds in this group (Orders Falconiformes and Strigiformes) are hawks, owls, and vultures. Less common are eagles, ospreys, and some of the falcons. The California condor is quite rare.

Army Activities That Affect the Attribute

Since birds of prey nest primarily in trees — sometimes in areas remote from human habitation — cutting of mature timber stands or the selected removal of overmature or noncommercial individual trees could result in a reduction in their numbers. Burning of brush or grasslands, applications of herbicides and pesticides, and the use of poisoned bait in animal-control programs are other activities that could directly affect the survivability of predatory birds. Field-training activities resulting in intrusions by persons into or near nesting areas could affect these birds, particularly eagles, ospreys, condors, and some types of falcons that are less tolerant of man.

Source of Effects

The removal of nesting trees as a part of any general land-clearing program preceding construction activities or the selected removal of such trees in a forest-management "sanitation" cutting could destroy unhatched eggs or cause the death of birds too young to survive outside the nest. If suitable nesting habitat is not available elsewhere in the vicinity, adult birds may disappear from an entire area. Burning of brush and grasslands destroys the habitat and large numbers of the prey species (small animals) on which predatory birds depend for food. Similarly, application of defoliants could reduce the food and cover available for small animals and birds with a consequent reduction in their numbers. The effects of pesticides on birds of prey are not subject to universal agreement, but considerable evidence supports the proposition that the reproductive capacity of these birds may be reduced if sufficient quantities of DDT and other chlorinated hydrocarbon insecticdes are

concentrated in the food by ingest. As an example, egg shells can be weakened to the point where they break before the young are ready to emerge. Direct killing of predatory birds can result from their eating of poisoned bait (portions of animal carcasses) intended for coyotes, cougars, and other flesh-eating animal predators. Extensive field-training activities resulting in the visibility of man and the noise of vehicular equipment and weapons firing — if conducted intensively over an extended period of time, or at frequent intervals — could cause birds to desert their nests. If the activity is sustained over a long enough period of time, adult birds may leave the area permanently.

Variables to be Measured

The number and types of birds of prey that nest and/or capture their food within the affected area should be determined. The change in the amount of available habitat (nesting and/or feeding) must be ascertained to estimate the numbers of birds which the existing habitat will support once the activity is completed or the project becomes operational.

How Variables are Measured

While a direct census of common birds of prey is possible in areas of limited size, the observational and general outdoor skills and the time required make it most impractical to conduct one. A useable population figure could be best obtained from a local wildlife biologist affiliated with a Federal or state wildlife agency. Such a biologist of the Audubon Society, Isaak Walton League, or similar private wildlife conservation organizations should be able to provide accurate counts of the less common species and the locations of their nesting and feeding areas.

The change in acreage of nesting and feeding habitats can be obtained from before and after overlays prepared from aerial photographic prints, mosaics, or topographic maps. Through the use of a planimeter, the size of these areas can be determined with the assistance of an engineer or surveyor. For the more common species of hawks and owls, the nesting and feeding habitats can be combined and a direct proportion established between the bird population and the number of acres of available habitat. The following equation reflects this relationship:

$$\text{Future Population} = \frac{\text{Present Population} \times \text{Future Habitat Acreage}}{\text{Present Habitat Acreage}}$$

The relationship between available habitat and the generally larger, less numerous predatory birds is less direct and more subjective. If such species as the bald eagle, golden eagle, osprey, peregrin falcon, or California condor are present in an area, it would be best to solicit the opinion of expert wildlife biologists in determining what portion of the existing population would remain after the activity was completed.

Evaluation and Interpretation of Data

The change in numbers of common birds of prey as related to a particular activity and location is an overall indicator of the change in habitat quality for other birds and animals within the area. Any substantial reduction in the numbers and types of hawks and owls would be generally indicative of a rather adverse ecological impact. As with the large-wild-animal attribute, any reduction of the less common species of avian predators could be expected to bring forth objections from private conservation organizations as well as from Federal and state agencies charged with their management and protection.

Special Conditions

If any of the predatory birds of the area are considered to be threatened (formerly categorized as rare or endangered) — regionally, nationally, or internationally — any reduction in their numbers resulting from the Army activity, particularly habitat alteration, would likely be controversial. (The attribute write-up covering threatened species goes into greater detail on this subject.)

Geographical and Temporal Limitations

Most of the large, less common birds of prey have very restricted geographic ranges. Maps showing these ranges are contained in most field guides to bird identification. A review of such range maps would reveal whether or not these species are likely to be found in the activity area. Special attention should be given to any short-term activities that might disturb the birds during their nesting season.

Mitigation of Impact

The potential detrimental impact of Army activities on the avian predator population can best be mitigated by locating the activity at places not considered a part of the habitat essential for the survival of these birds. This is best accomplished during the site selection planning stage of a project rather than after a specific site has been chosen. Unless operational considerations are absolutely overriding, the habitat of the large, uncommon species should not be disturbed at all. Regular or sustained intrusions of men or equipment into nesting areas should be avoided to the maximum possible extent, especially while eggs are being incubated by the adults and until the young have left the nest. No known nests should be destroyed by the sanitation cuttings of noncommercial individual trees.

Other Comments

If the existing habitat of the bald eagle, golden eagle, osprey, peregrin falcon, or California condor is threatened by an Army activity, the resultant controversy is likely to be intense, prolonged, and acrimonious.

Additional References

SMALL GAME

Definition of the Attribute

Small game includes both upland game birds and animals which as adults weigh less than 30 pounds and are commonly hunted for sport in the area that might be affected by an Army activity. Some small game species falling into this category are rabbits, squirrels, raccoon, quail, grouse, and pheasant.

Army Activities That Affect the Attribute

Since most small game animals and upland birds are very tolerant of humans, Army activities most damaging to them are those which physically destroy their habitat (area in which all welfare factors such as food, cover, water, and space required for their survival and propagation are present in sufficient quantity and diversity). Land-clearing activities for buildings, road construction, etc., are most often the ones that significantly and adversely affect small game. Conversely, such game can be expected to return to formerly built-up areas which are abandoned and allowed to revert to native vegetation. Distribution of poisoned baits used in rodent and predator control and use of herbicidal defoliants can also reduce small game populations.

Source of Effects

The removal of native vegetation from an area or the rearrangement of its topography and surface features by grading denies small game the kind of habitat they require. Without the food and cover provided by vegetation and irregular surface features, populations of small game diminish rapidly. Conversely, they will quickly return to abandoned areas given over to native vegetation.If poisoned bait is used, only a few small game animals and birds are likely to be affected except in winter when food is scarce and populations are at their annual minimum. Herbicidal defoliants temporarily destroy small game habitat, and repeated applications can cause the permanent abandonment of an area.

Variables to be Measured

The small game population of the area to be affected by the activity must be censused. Once this is accomplished, the number of acres of existing habitat must be determined as well as the amount by which it will increase or decrease over time as a result of the activity. The relationship between these variables and the attributes is fairly straightforward – the carrying capacity (wildlife population an area can support indefinitely without habitat degradation) is increased or decreased in direct proportion to the amount of available habitat. While the quality of small game habitat existing before and available after the completion of an activity is an important variable, it is very difficult to quantify and will not be specifically discussed. It will however, enter into subjective evaluations and judgments.

How Variables are Measured

While an accurate census of small game is difficult to make, usable estimates of the number of different species per acre of habitat can often be obtained from local wildlife biologists affiliated with Federal or state wildlife agencies.

The change in acreage of small game habitat can be obtained from before and after habitat overlays prepared from aerial photographic prints, mosaics, or topographic maps. Through the use of a planimeter, the size of these areas can be determined with the assistance of an engineer or surveyor. A direct proportion can then be established between the small game population and the number of acres of suitable habitat. The following equation reflects that relationship:

$$\text{Future Population} = \frac{\text{Present Population} \times \text{Future Habitat Acreage}}{\text{Present Habitat Acreage}}$$

Evaluation and Interpretation of Data

The relative importance of a change in the small game population of an area is a very subjective judgment. If habitat is to be destroyed, significance should be attached to the relative amount and quality available in adjacent areas as well as to the relative amount and quality of total habitat under the Army's control that will remain after the activity is completed.

Special Conditions

If the Army activity will cause a significant reduction in the available small game habitat in an area subject to heavy hunting, the impact will likely be controversial to both sportsmen and – to a lesser extent – economic interests in the area. This could happen not only if habitat is destroyed but also if a prime small game hunting area is fenced and placed off limits to the general public.

Geographical and Temporal Limitations

While it is unlikely that any small game species would fall into the threatened (formerly categorized as rare or endangered) category nationally, certain ones such as grouse, woodcock, and turkey might be rare in some states or local areas. Field training activities during nesting season often destroy eggs, the result of which may be a significant reduction of the game-bird population for one or more years.

Mitigation of Impact

Army activities affecting small game can best be mitigated by disturbing the vegetative cover and altering the physical contour of the land as little as possible. Selecting areas of poorer habitat quality and preserving prime areas will reduce the severity of its impact on the small game population. Opening of Army reservations to the general public during certain periods of the small game hunting season (opening day and holidays when hunting pressure is particularly heavy) will also tend to ameliorate the loss of areas formerly open to public hunting.

Other Comments – (None)

Additional References

FISH, SHELLFISH, AND WATERFOWL

Definition of the Attribute

Fish are cold-blooded, aquatic animals that obtain oxygen through a gill system. They inhabit saltwater and freshwater bodies and streams and vary widely in size. Common species are minnows, sunfish, trout, bass, pike, salmon, tuna, and sharks.

Shellfish are aquatic animals that have an exoskeletal shell rather than an internal vertebrate structure of backbone and ribs. Common freshwater and saltwater species are mussels, crayfish, clams, oysters, shrimp, crabs, and lobsters.

Waterfowl are birds which frequent and often swim in water, nest and raise their young near water, and derive at least part of their food from aquatic plants, animals, and insects. Ducks and geese are the most familiar waterfowl. Because of similar habitat requirements, the generally protected swans, herons, cranes, pelicans and gulls are also included here. The whooping crane is a frequently cited example of a threatened species that falls into the waterfowl category.

Army Activities That Affect the Attribute

Since fish, shellfish, and waterfowl depend directly upon water for all or some facets of their existence, Army activities which affect water quality and water level have the greatest impact upon their well-being. Examples of particularly damaging activities are dredging, stream channelization, construction that exposes mineral soil and subsoil which is subject to erosion, disposal of untreated or insufficiently treated sewage in water courses, permitting toxic materials to drain into water courses without collection and treatment, disposing of cooling water in the ocean or in streams and lakes, application of pesticides – the residue of which may drain into water courses, draining of swamps or potholes, building of water-level control structures such as dams or dikes, and disposal of containerized toxic gases and residues at sea.

Source of Effects

Dredging can temporarily displace the bottom organisms on which these categories of wildlife feed and can destroy spawning grounds. Stream channelization results in the removal of native vegetation which supports the insects eaten by fish. In addition, alteration of flow and substrate characteristics resulting from stream channelization can be as harmful as loss of vegetation. Certain species of fish are affected by even small amounts of solid material suspended in the water, a condition resulting from dredging or soil erosion. Some species of fish and shellfish are affected by siltation which can both cut off their oxygen supply and reduce the availability of food. Discharge of insufficiently treated sewage may introduce disease-causing bacteria and viruses and reduce the oxygen content of the water – the life-support system upon which fish and shellfish are totally dependent. Insufficiently treated sewage also introduces nutrients into the water which accelerate plant growth, often affecting the quantity of available fish habitat by further reducing the oxygen supply. Toxic materials such as oils spilled or draining into water courses cause the feathers of waterfowl to no longer shed water, bringing about death from exposure. Toxic materials such as mercury can eventually be so concentrated in the food chain that fish are no longer safe for man to eat. Other toxic materials can cause the outright death of fish by damaging their gills and preventing them from extracting oxygen from water. The acidity level of water if too high (pH 5 or less) or too low (pH 11 or greater) can cause similar gill damage. Increases in water temperature often cause sport fish to abandon the area to less desirable species of so-called rough fish such as carp. Rapid fluctuations in water temperature can kill fish outright. Pesticide residues draining into water courses and concentrating through the food chain may eventually become present in sufficient quantities in fish to cause their reproductive capacity and survivability of young to be impaired. Pesticides can become even more concentrated in certain organs of fish-eating birds and animals. Draining of swamps or potholes is very detrimental to waterfowl as it is near these bodies of water that reproduction, nesting, and the rearing of young take place. The artificial raising and lowering of water levels is often beneficial to wildlife habitat if done at times consistent with needs for food and nesting cover. However, since changing of water levels is most often a flood-control requirement, fish and waterfowl habitat can be drastically affected by changes not in consonance with their needs. Depending on the lethality of the material, the rupturing of containers of toxic substances disposed of at sea could cause the destruction of all aquatic life in both the immediate area and other areas where the substance is transported by ocean currents.

Variables to be Measured

The variables to be measured for fish are those identified in the attribute descriptions involved with surface-water quality. Some of these variables are dissolved-oxygen content, coliform-bacteria levels, acidity levels (pH), heavy-metal concentrations, and insecticide concentrations which are detrimental to fish life.

While many substances (petroleum products, hydrogen sulfide, copper, and other metals) can taint shellfish and make them unpalatable by reason of odor, taste, or color; pathogenic bacteria and viruses which they take up from the surrounding water may render them unfit for human consumption. Measurements of coliform bacteria present in the water provide a standard for determining when oysters, clams, and muscles can be safely eaten.

The main variable to be measured for waterfowl is change in available habitat. Quantity of suitable nesting habitat – which equates to the length of shoreline – is a heavy determinant of waterfowl population on a year-to-year basis, but it is difficult to relate the two directly. Winter habitat is also important but more difficult to quantify and relate to increases or decreases in waterfowl.

How Variables are Measured

As indicated, measurements of water-quality variables are discussed under surface-water quality. Some acceptable general standards for maintaining a healthy aquatic fish habitat are that dissolved oxygen content should not fall below 5 milligrams per liter and that pH level should be maintained in the 6 to 9 range. The Federal Environmental Protection Agency (EPA) has published a draft report which specifies limits for pollutants within various water use categories, several sections of which deal with aquatic life. Prior to formal publication of the report, these standards are available in summary form in the *Environment Reporter*.[1]

While the standards for fish also apply generally to shellfish, coliform bacteria count is the important variable to be measured. Criteria for water from which shellfish are harvested are contained in the U.S. Public Health Service Manual, *Sanitation of Shellfish Growing Areas*. General standards for coliform bacteria are that the median most probable number (NPN) must not exceed 70 per 100 milliliters.

If the length of existing shoreline or its character is altered so as to render it unsuitable for waterfowl nesting, the amount of change should be determined. Before and after overlays of suitable wildlife nesting habitat along shorelines should be prepared from aerial photographs, project plans, or maps. Through the use of a map measurer (the specific instrument name for a very precise odometer) and with the assistance of an engineer, cartographer, or a photointerpreter, shoreline length can be determined. The amount of change between present and future habitat can then be calculated. Additionally, the change in number of individual bodies of water between the two overlays should be noted. Once these data are obtained, they are still not directly convertible to changes in the number of pairs of nesting waterfowl the habitat can support. This is a subjective judgment which only an expert wildlife biologist, e.g., from the U.S. Fish and Wildlife Service, can make.

Evaluation and Interpretation of Data

Although it is difficult to relate alterations in water quality to changes in fish and shellfish populations, changes in fecundity, population counts, and growth rates are often sensitive indicators of such alterations. Therefore an attempt should be made to assess population changes that might result from proposed alterations of the environment. If water quality is degraded or improved to the point where commercial fishing activities are affected, the change in annual revenues derived from this source can be determined. If the change in water quality affects species associated with sport fishing, the number of miles of streams affected would provide some measure of the significance of the impact. If a prime sport-fishing area is involved, economic gains or losses to businesses deriving a part of their income from fishermen might be an important consideration. Estimates of the effects of such changes might be obtained from Federal or state wildlife agencies.

Changes in quantity of nesting habitat would definitely affect the number of waterfowl available for annual harvest. However, the effect is felt more in areas where waterfowl are hunted than where they nest. An expert from the U.S. Fish and Wildlife

Service could provide an insight into the extent of the e resulting environmental (ecological and economic) impacts.

Special Conditions

If Army activities will cause a significant reduction in the length of streams or areas of coastal waters suitable for sport fishing or in the amount of waterfowl nesting habitat, the impact will likely be controversial to sportsmen. This could happen if even small stretches of trout streams were to be affected or if prime fishing waters were placed off limits to the general public. Commercial interests would most likely oppose any intrusion into prime fish and shellfish areas or any reduction in the annual catch/harvest. If any waterfowl that are considered to be threatened (formerly categorized as rare or endangered) – regionally, nationally, or internationally – use the activity area for nesting, migration stopover, or feeding, significant controversy would likely result. (The attribute write-up covering Threatened Species goes into greater detail on this subject.)

Geographical and Temporal Limitations

The only geographic limitations on fish and shellfish relate to particular types found in the activity area and whether coastal estuaries or open-sea areas are involved. Temporal considerations are those involved with conducting the activity during spawning, migration, or harvest seasons.

The critical region of waterfowl nesting habitat is generally considered to be in states adjacent to the Canadian border and in Alaska. This would, however, not be true of nonmigratory waterfowl associated with estuaries and seacoasts. Activity which would disturb waterfowl during nesting season and while the young are being reared would be most damaging.

Mitigation of Impact

Impacts upon fish and shellfish populations can be mitigated by restricting the input of polluting substances into water courses, estuaries, and the open sea. This can best be accomplished by insuring that wastewater-treatment facilities of suitable capacity and design are constructed so as to be in operation by the time it is anticipated that waste products from the proposed project will be generated. If soil erosion is a problem, construction activities should be scheduled at times of the year when intense rainfall is least likely to occur.

Impacts on waterfowl from an activity can best be mitigated by disturbing the land/water interface in the area as little as possible. Vegetation along water courses should not be cleared indiscriminately. Neither should potholes or swamps be drained unless absolutely necessary for successful completion of the activity. Additionally, when a part of the activity involves water-level control, changes in such levels should be programmed – to the extent it is possible to do so – in a way that will only minimally disturb nesting and feeding habitat. These considerations for the natural environment will help to insure that waterfowl habitat available for nesting and feeding is not appreciably diminished in either quantity or quality.

Other Comments

Water quality and fish and shellfish habitat go hand in hand. Any substantial degradation of the former will have a decided impact on the fish and shellfish populations relative to both quality and number. All aquatic oxygen-using (aerobic) organisms will be affected to some degree by decreases in water quality. The effect of an activity on fish and shellfish is a general indicator of the impact on the entire water environment.

Additional References

FIELD CROPS

Definition of the Attribute

Field crops are those commercially cultivated by man for the primary purpose of providing food and clothing for himself and food for domestic livestock. Common field crops include corn, wheat, cotton, soybeans, and truck produce (tomatoes, melons, and table vegetables).

Army Activities That Affect the Attribute

Since almost all land suitable for field crops is in private ownership, acquisition of that land by the Army – for whatever specific purpose – would take it out of agricultural production. Acquisition of prime agricultural lands for new military installations or for the expansion of existing ones is the Army activity likely to have the greatest impact on field crops. Application of herbicides on Army controlled land adjacent to an agricultural area planted in field crops would have a more localized impact.

Source of Effects

Diversity – both man-made and natural – is an important and valuable characteristic of ecosystems. If the area previously given over to field crops is to be built upon (the most likely reason for acquiring the relatively flat land that field crops usually occupy) or is to be used extensively for training or field test activities, the vegetative diversity will be reduced. Wildlife could also be affected as many game and nongame animals and birds obtain food and cover from field crops. If the acquired land is allowed through successive vegetative stages to revert to the natural climax type of area, the impact might be ecologically beneficial.

Herbicides applied by aerial spraying on Army land – especially to suppress vegetation along security fences – might carry onto adjacent agricultural land, killing crops with which they come in contact. While the area might be relatively small, the resulting damage could be highly controversial.

Variables to be Measured

The main variables to be measured are the number of acres of land now given over to field crops which would be taken out of production and the percentage of that land which would be permitted to revert to natural vegetation. Since field crops and vegetation are both ecologically important, an assumption can be made that if one type is not unduly created at the expense of the other, each is of equal significance. The measure of ecological impact would then be determined by the loss of productive vegetative cover.

How Variables are Measured

Specific acreages of field-crop land to be taken out of production by a land-acquisition program could be measured directly, but it would be easier to obtain figures from local offices of the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture. Land previously used for crops but permitted to revert to natural vegetation should be depicted on an overlay prepared to scale from a project plan, a map, or an aerial photograph. Through the use of a planimeter, the size (acreage) of that area can be determined with the assistance of an engineer or surveyor. The percentage of crop land reverting to natural vegetation could be derived from the following equation:

$$\text{Percentage of Land Reverting to Natural Vegetation} = \frac{\text{Area Reverting to Natural Vegetation}}{\text{Total Area of Crop Land}} \times 100.$$

Only a general estimate is possible when determining field-crop acreages that might be damaged by herbicidal spraying. Some of the variables involved would be the kind of application system used, wind direction and velocity, and state of crop development. However, if these variables are reduced to an assumption that 500 feet is the maximum distance into the field that the herbicide could produce crop damage, the other variable involved would be the linear measure of crop land directly adjoining the area where the herbicide is to be applied. Solution of the following equation would provide a quantitative measure of this effect:

$$\text{Acres Affected} = \frac{\text{500 Feet x the Linear Measure of Crop Land Affected (feet)}}{\text{43,560 Square Feet}}.$$

This effect could then be translated into economic terms through the use of another equation:

$$\text{Economic Returns Foregone (\$)} = \frac{\text{Acres Affected} \times \text{Average Yield Per Acre (bushel, ton, etc)}}{\times \text{ Selling Price Per Unit}}$$

The ASCS should be able to provide acreage yields and selling prices of various field crops which might be affected.

Evaluation and Interpretation of Data

The magnitude of the impact of the change in land use that results from crop-land acquisition is related to the percentage of that land which will continue to support natural vegetation. The greater the percentage of field-crop land that is built upon or otherwise taken out of vegetation production, the greater the impact. For crops damaged by application of herbicides, a measure of impact could be made by comparing the dollar loss of the destroyed crops to the annual value of that crop in the country or area concerned. Again, the greater the percentage the dollar loss is of the total crop value, the greater the impact.

Special Conditions

If the crop land is especially productive relative to other crop land in the general area or if the crop grown upon that land is of very high value, the impact may be greater than what would otherwise be anticipated.

Geographical and Temporal Limitations

Because of climate and soil or other requirements, some field crops – particularly truck crops (avocados are a good example) – can be grown only in a very limited geographic area. If the crop land to be acquired by the Army is in such an area, a significant reduction in the total output of that crop might result. On the other hand, there are vast areas in the Western United States where conditions are not suitable for the cultivation of field crops. Army land-acquisition activity in those areas would not affect this attribute.

Herbicidal damage to field crops is greatest when the plant is growing fastest (spring) before the vegetative product (corn ears, grain kernels, bean pods) has matured. However, this is generally the time when herbicides will be used because they have the greatest suppressive effect on vegetation at which they are directed.

Mitigation of Impact

The detrimental impact of acquiring productive field-crop land for Army activities can best be mitigated by locating the activity in an area where very little land is given over to field-crop production or where the farming enterprise is of marginal economic value. Some additional mitigation is possible if a large portion of the crop land is allowed to revert to natural vegetation. This would be possible in buffer areas acquired to shield private lands from Army training areas or to provide security for research tests and development activities.

Mitigation of the impact of herbicidal applications could take the form of cutting vegetation and applying the herbicide directly to the stumps in those areas where field crops directly adjoin Army installations. Further mitigation of impact is possible if the stump application of herbicides is done at a time when the adjacent field crops are vegetatively dormant. If spraying is a preferred method of vegetative suppression, it should be done at times when wind velocity is low and wind direction is such that the possibility of the herbicide carrying into the field-crop area is minimal.

Other Comments

If significant economic loss will result from the Army's acquisition of crop land and its removal from agricultural production, farmers' organizations would be likely to actively oppose the project.

Additional References

THREATENED SPECIES

Definition of the Attribute

Threatened species (formerly categorized as rare or endangered) include all forms of plant and animal life whose rates of reproduction have declined to the point where their populations are so small that they are in danger of disappearing. Threatened species are classified as such on a state and national basis. A species classified as threatened within a state may occur only in limited numbers at a very few locations within that state but be common in other states. National threatened species are those found only in very small numbers or those near extinction in the United States. Lists of threatened animal species are published periodically by the Bureau of Sport Fisheries and Wildlife of the U.S. Department of Interior.[2] Examples of more commonly known threatened species are the alligator, timber wolf, grizzly bear, Southern bald eagle, and whooping crane. Less commonly known threatened species include the black footed ferret, key deer (Florida), Devil's Hole pup fish, Florida kite, and Delmarva fox squirrel. While animal species are the ones most often in the public eye, there are probably many species of plants that would also qualify as threatened. The coast redwood is already a candidate for popular interest in this category, and others seem certain to gain public attention.

Army Activities That Affect the Attribute

These activities are basically the same, depending on the animal or plant species involved, as those mentioned under the Large Animals, Predatory Birds, and Natural Land Vegetation attributes. Refer to those sections if a threatened species' habitat is located within the geographic area that a specific Army action with affect.

Source of Effects

The source of the effects of Army activities on threatened species of animals and plants is essentially the same as those listed for Large Animals, Predatory Birds, and Natural Land Vegetation. Refer to those attributes if the habitat of a threatened species is located within an area where the effects of a particular Army action will be felt.

Variables to be Measured and How Variables are Measured

The variables to be measured and the method of doing so are highly dependent upon the particular species of plant or animal affected. While the information contained in similar parts of the attribute write-up for Large Animals, Predatory Birds, and National Land Vegetation could serve as a general guide in the case of threatened species, the assistance of an ecological team of wildlife biologists, zoologists, botanists, and plant physiologists in accumulating relevant data would be almost a necessity.

Evaluation and Interpretation of Data

This function can be adequately carried out only by a group of professional ecologists familiar with the myriad details associated with the threatened species itself, its place in the ecosystem, and the nature of the particular habitat which is to be impacted. Logically, this team of ecologists should be the same group responsible for collection of the basic data on which the evaluation is to be based. However, an additional critical review of their conclusions by an eminent ecologist might help to insure public acceptability of those findings.

Special Conditions

All Army activities, their impacts, relationships of variables, measurement and interpretation of variables, and geographic limitations discussed in the other ecological attributes apply to threatened species as well. However, the significance of impacts of Army activities on these species is considerably greater. The complete disappearance of a plant or animal species represents the loss of a component of the ecosystem which may adversely affect the way in which the system functions. Genetic information carried by these organisms is permanently lost. Impacts on threatened species are also indicative of stress imposed on other elements of the ecosystem.

Geographical and Temporal Limitations – (None)

Mitigation of Impact

The primary way to mitigate the impact of Army activities on threatened species is to avoid any disruption – physical or biological – of their habitat

which might result in a decrease in their populations. While it would be less damaging to disturb the habitat of a species classified as threatened by a state than one that is threatened nationally or one that is rare rather than endangered, these trade-offs are usually not feasible. It is best to avoid disturbing the known habitat of any threatened species.

Other Comments

If any Army activity has the potential of adversely affecting the populations of any threatened species, naturalist and wildlife groups are almost certain to vigorously oppose it in public hearings and/or in court.

If any question exists as to the presence of a threatened species — either intermittently or year-round — in the area of a project, local wildlife biologists or botanists should be called upon to verify that presence and to give a preliminary assessment of the impact of the activity on the population of this species.

Additional References

NATURAL LAND VEGETATION

Definition of the Attribute

Natural land vegetation is that which uses soil (as opposed to water) as its growth medium and which is not the subject of extensive cultural practices by man. Included in this category are a number of diverse groups of plants, including trees, shrubs, grasses, herbs, ferns, and lichens.

Army Activities That Affect the Attribute

Any activities that affect land surface will affect the vegetation that grows upon it. Timber-harvest operations, land-clearing activities prior to construction, controlled burning, application of herbicides, mechanized field training, and the application of artificial paving materials are some activities that can cause adverse impacts on natural vegetation. Abandonment of Army facilities can result in natural vegetation becoming reestablished through a series of successional stages.

Source of Effects

Timber-removal operations employing inappropriate forest-management methods can reduce the possibility of reestablishing fully stocked stands of the same species. Without the protection of the forest canopy, shrubs and other plants left after timber removal may weaken and become prime targets for disease and insects. Land-clearing activities can cause the outright destruction of natural vegetation and resulting soil erosion can inhibit its reestablishment. Controlled burning can bring about destruction of all but mature timber species and, eventually, reduce soil fertility. Improper use of herbicides can result in the destruction of nontarget species of natural vegetation and disrupt the overall stability of the ecosystem. Mechanized field training destroys lower vegetative forms outright, and the resultant soil compaction and erosion — each in its own way — can inhibit their reestablishment. Paving can deny native vegetation to large areas for extended time periods. As previously indicated, a reduction in the magnitude of activity at a particular installation or its closing can encourage the reestablishment of native vegetation.

Variables to be Measured

The variables to be measured are the numbers of acres of native vegetation existing before and after the activity, as well as any significant vegetative changes that may develop. A reduction in an area given over to native vegetation can result in increased soil erosion, a decrease in soil fertility, and a decrease in quality and quantity of wildlife habitat. It can also accelerate the invasion of weeds and other undesirable pest species. Reintroduction of native vegetation can – over time – have the opposite effect. Successional change in vegetative type is slow, however, and the least-desirable plant types are the first to become reestablished on a site after a major clearing activity.

How Variables are Measured

The change in acreage of natural vegetation can be obtained from before and after overlays of vegetative types. The before overlay can best be prepared from recent aerial photographs. A photointerpreter can assist in differentiating and plotting the major vegetative types. In this way, the total area of vegetation cover can be ascertained along with the subareas in each of the major types. The after-activity overlay should be prepared at the same scale, using the project plan to outline areas of existing natural vegetation which will be affected. The remaining total acreage in native vegetation by major type should then be determined. These calculations of acreage can best be done through the use of a planimeter and with the assistance of a photointerpreter or an engineer. The percentage of original native vegetation remaining – both total and by major type – could be derived from the following equations:

$$\text{Percentage of Land Remaining in Natural Vegetation} = \frac{\text{Area After Project}}{\text{Area Before Project}} \times 100$$

$$\text{Percentage of Particular Vegetative Type Remaining} = \frac{\text{Area and Type After Project}}{\text{Area and Type Before Project}} \times 100$$

Evaluation and Interpretation of Data

The magnitude of the impact of the activity on natural vegetation can be determined from the percentages previously given. However, the specific changes and types of vegetation which would result from the activity could be projected only by a botanist or forester intimately familiar with the local area. Even more difficult to interpret objectively are the aesthetic considerations involved. Secondary impacts resulting from changes in wildlife population, sediment loads in streams, and soil fertility are treated in other attribute descriptions.

Special Conditions

Destruction of natural vegetation in particularly fragile ecosystems that exist under extremely adverse environmental conditions – such as tundra and desert – can have greater impact than in an area with a more moderate climate.

Geographical and Temporal Limitations

The only geographic limitations of impacts on this attribute occur in those rare areas of desert and bare rock where no native vegetation exists. No temporal limitations are evident.

Mitigation of Impact

The best way to mitigate the impact of Army activities on natural vegetation is to design the project so as to restrict the area affected. Examples of other mitigation possibilities are to restrict land-clearing activities to the absolute minimum, apply ecologically sound management practices in timber harvest and timber-stand improvement, confine mechanized training activities to designated areas and restrict expanding them into new areas, apply vegetation-suppression techniques of controlled burning and herbicide application only when other methods are not feasible, and use crushed stone rather than asphalt or concrete for surfacing parking areas.

Other Comments

If Army activities result in the destruction of unique areas of natural vegetation, opposition can be anticipated from local and national naturalist organizations. These natural areas are usually well known locally and are often cataloged at the state level by departments of natural resources. Any activity that would alter these unique and rare areas of natural vegetation should be avoided to the same extent as one involving the habitat of a threatened species of wildlife.

Additional References

AQUATIC PLANTS

Definition of the Attribute

Aquatic plants are those whose growth medium is primarily water but which may be rooted in soil. They include free-floating plants such as phytoplankton, all surface and submerged rooted plants, and swamp and marsh vegetation whose roots are periodically or permanently submerged in water. Aquatic plants are essential elements in the food web.

Army Activities That Affect the Attribute

Army activites which cause changes in water level or water-quality parameters have the greatest impact on aquatic plants. Examples of particularly damaging activities are dredging, stream channelization, construction that exposes mineral soil and subsoil subject to erosion, disposal of untreated or insufficiently treated sewage in water courses, disposal of cooling waters in oceans and in streams or lakes, draining swamps and marshes, and building of water-level-control structures such as dams or dikes.

Source of Effects

Dredging can temporarily – and sometimes for long periods – displace rooted and bottom-dwelling aquatic plants. Stream channelization removes all stream-side vegetation. Erosion can cause increased sediment loads sufficient to restrict the sunlight on which aquatic plants depend for photosynthesis. The discharge of insufficiently treated sewage into the water courses induces excessive aquatic plant growth. Increases in temperature also tend to accelerate aquatic plant growth, particularly algae. The draining of swamps and marshes reduces the area in which aquatic plants can survive. Changes in water level can cause the destruction of aquatic plants, either by exposing their roots to the drying influence of sunlight and air or by flooding to levels which deny air to bank- or marsh-dwelling species for long periods of time.

Variables to be Measured

The essential variable is the change in amount of water area suitable for the growth of aquatic plants. There are two elements to this variable – changes in water surface areas and changes in those elements of water quality which accelerate or restrict plant growth. Any changes in the kind of vegetation and its productivity can influence all other organisms that depend upon it for food.

How Variables are Measured

The only direct measurement that can be readily made is the quantity of total aquatic plant habitat available before and after the activity. This can be done by an expert photointerpreter who should prepare before and after overlays from large-scale aerial photography. He can then measure the acreage in those areas with a planimeter. The percentage change in total available aquatic habitat can then be derived from the following equation:

$$\text{Percentage Change in Aquatic Habitat} = 100 - \left(\frac{\text{Area After the Project}}{\text{Area Before the Project}} \times 100\right)$$

The quality of the water habitat existing before and after the project can be ascertained only by intensively examining the aquatic plant life, measuring the various water-quality parameters affecting plant growth, projecting changes in water quality that will result from the activity, and projecting the changes in aquatic plant habitat that will follow. This is a complex procedure which can best be accomplished with the assistance of an interdisciplinary team of biologists, botanists, zoologists, ecologists, and engineers.

Evaluation and Interpretation of Data

Since it is not possible to directly measure the change in the quality and quantity of aquatic plant life, only a very imprecise measure of impact can be obtained from the change in water area. Generally, if the percentage change in aquatic plant habitat exhibits a value greater than 20, an attempt should be made to measure the qualitative change as well. Further, if changes in the water-quality parameters measured or projected under surface water attributes indicate increased nitrogen and phosphorous concentrations, increased water temperature, decreased water flow, or high sediment loads, the advice of ecological experts should be sought relative to the extent of the impact on aquatic life.

Special Conditions

If the change in quantity, quality, or type of aquatic vegetation will result in waters outside the Army installation being rendered unfit for swimming or will cause a reduction in the game- or commercial-fish populations, greater controversy over the project is likely to result since the impact will be more directly felt by the general public.

Geographical and Temporal Limitations

The only geographical limitations on aquatic vegetation are the particular types native to certain areas. Temporal considerations do not appear to be significant.

Mitigation of Impact

Impacts on aquatic plant life can best be mitigated by minimizing the input of nutrients, erosion products, and heat into water bodies. This can be accomplished by assuring that wastewater-treatment facilities of appropriate size are constructed so as to be in operation by the time the increased amount of nutrients is scheduled to be generated. If soil erosion is a problem, catch basins can be constructed to permit the settling out of suspended solids prior to the runoff water reaching natural water bodies. (The attribute write-up covering erosion goes into greater detail on this subject.) Additionally, construction activities can be scheduled at times of the year when intensive rainfall is least likely to occur. Cooling water can be processed or stored in artificial ponds until the difference in temperature between it and the receiving water is more nearly equal.

Swamps and marshes should not be drained unless such action is absolutely necessary for the successful completion of the activity. Artificial changes in water level should be minimized and programmed during the fall and winter when the plants are dormant. If herbicides are used to suppress excessive aquatic plant growth, they should be applied selectively and in amounts that will reduce the undesirable species but not kill all aquatic plants.

Other Comments

Water quality and quantity are directly related to the suitability of water bodies for desirable aquatic plant growth. Introduction of pollutants will reduce plant productivity and plant species diversity and result in an aquatic plant community composed predominantly of pollution-tolerant forms. This will in turn have a decided impact on the fish population that inhabit the waters. Changes in the food web can have impacts throughout the ecosystem, but these are often not completely understood.

Additional References

REFERENCES

(1) *Environment Reporter,* Volume 4, Number 16 (August 17, 1973), pp 663 and 669.

(2) *Threatened Wildlife of the United States,* 1973 Edition, Resource Publication 114, U.S. Department of Interior Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, U.S. Government Printing Office, Washington, D. C. (March, 1973).

SOUND

The level of sound (noise) is an important indicator of the quality of the environment. Ramifications of various sound levels and types may be reflected in health (mental and physical) and/or in aesthetic appreciation of an area. Because of the important consequences of a too-noisy environment, this resource, sound, is examined separately rather than under various other resource categories.

The sound (noise) in an environment is indicated by many attributes, but the selected ones are:

- Physiological Effects
- Psychological Effects
- Communication Effects
- Performance Effects
- Social Behavior Effects.

PHYSIOLOGICAL EFFECTS

Definition of the Attribute

Noise can affect the physiology of the human body in three important ways:

Internal bodily systems
Hearing threshold
Sleep pattern.

Internal bodily systems are defined as those physiological systems essential for life support, i.e., cardiovascular (heart, lungs, vessels), gastrointestinal (stomach, intestines), neural (nerves), muscoskeletal (muscles, bones), endocrine (glands). Noise stimulation of nerve fibers in the ear may indirectly harmfully affect these systems. High-intensity noise (e.g., artillery fire, inside tracked vehicles) constricts the blood vessels, increases pulse and respiration rates, increases tension, and fatigue, and can cause dizziness and loss of balance.[1-3] However, these effects are generally temporary; and to come extent adaptation does occur. The process of adaptation is in itself indicative of an alteration in body functions and is, therefore, undesirable. Persistent effects have been reported (people working for years in high-noise-level environments), but these reports remain unproven at this time.[2] High noise levels can also reduce precision of coordinated movements, lengthen reaction time, and increase response time, all of which can result in human error. Those people (particularly the elderly) who have circulatory problems, chronic heart disease, or tension-related diseases may be adversely affected by high noise levels.[1]

Hearing threshold is defined as the lowest sound level or loudness of a noise that can be heard. The lower the sound level that can be heard, the lower the hearing threshold. If the sound level necessary for a noise to be heard (or the hearing threshold) is higher than normal, then hearing loss or partial deafness is indicated. Noise can cause temporary or permanent hearing loss (i.e., an increase in the hearing threshold) and can cause ringing in the ears (tinnitus). Hearing loss can be temporary in that the ear recovers relatively soon after the termination of the noise. Hearing loss of any degree is serious because accidents can occur if warning signals, commands, etc., cannot be heard or understood. In addition, hearing loss is undesirable from social, economic, psychological, and physiological points of view.

Sleep pattern is defined as a natural, regularly recurring condition of rest, and is essential for normal body and mental maintenance and recuperation from illness. Noise can affect the depth, continuity, duration, and recuperative value of sleep. The disruption or lack of sleep results in irritability, often irrational behavior, and the desire for sleep. Even a shift in the depth of sleep can result in fatigue. Also, while suffering or recovering from illness, rest and sleep are essential to health and recovery. Thus, it is important for noise to be kept at a minimum during night hours.

Army Activities That Affect the Attribute

Most Army activities cause some level of noise, but the most serious impacts are:

- *Construction.* Construction projects create noise through the use of vehicles, construction equipment, and power tools. The noise affects the operators, personnel, and communities near the site, and the people near transportation routes to the site.
- *Operation, Maintenance, and Repair.* The operation of all types of air/surface vehicles, machinery, power-generating equipment, and weapons will generate noise. Maintenance and repair produce noise through the use of all types of tools, and when a number of noise sources are operating at the same time in the same general area (e.g., a vehicle repair shop).
- *Training.* Training courses and exercises which use any type of vehicle, weapon, power tools, appliances, and machinery create noise for operators, military and civilian personnel, and, in large-scale exercises, can affect nearby civilian communities.
- *Industrial Plants.* The machinery and tools contained in these plants are a significant source of noise to the personnel and, if noise levels are sufficiently high, can affect the nearby community.
- *Research, Development, Testing, and Evaluation.* These types of facilities contain noise sources which could affect both personnel and communities. Examples include wind tunnels, machinery, and the testing of weapons, air/surface vehicles, and engines.

Source of Effects

The sources of noise which affect this attribute include:

- *Weapons.* Missiles and artillery of all types, including small arms, have extremely high noise levels and can severely affect the hearing threshold of their operators.
- *Vehicles.* Both combat and noncombat vehicles, in the air, on the ground, or on water are important noise sources which affect the operator, other personnel, and the community.
  Examples include:
  - aircraft on and around military air bases significantly affect the community; particularly sonic booms or night operation which can affect sleep patterns
  - combat vehicles such as tanks and armored personnel carriers can affect the hearing thresholds of the operators and passengers
  - noncombat vehicles when operated at night can affect the sleeping patterns of both military personnel and civilians.
- *Construction equipment.* These types of equipment which include vehicles and power tools have high noise levels which can affect hearing thresholds of operators and site personnel.
- *Machinery.* Machinery in industrial plants where noise levels are high, and continuous, can significantly affect operator hearing thresholds.

Variables to be Measured

The important variables of noise, which affect this attribute, are its **loudness**, **duration**, and **frequency content**. As the loudness and/or duration increase, the effects of noise on the body increases. The internal bodily systems are increasingly under stress, the hearing threshold increases to the point where permanent damage (called noise-induced hearing loss) can occur, and sleep becomes increasingly impossible. Noises which contain high frequencies or contain, or are, pure tones, are more damaging and disturbing than those which do not.

Finally, the **impulsivity** of a noise is important. An impulsive noise is highly intense and short in duration (generally less than 1000 μsec), e.g., artillery or small-arms fire. An impulsive noise is particularly important because it causes severe change in hearing threshold and can, if very intense, cause mechanical injury to the ear.[2,3]

How Variables are Measured

The **loudness** of noise is measured in terms of decibels (abbreviated as dB). Decibels are measured by using a sound-level meter. Normally, loudness is measured with a sound-level meter incorporating an "A" weighted electronic network.* The resulting measure is called dBA or dB(A). Most of the evaluation criteria are given in dB(A) units. The intensity of an impulsive noise may be difficult to read visually from a sound-level meter alone, due to the very short duration of the noise. To determine the intensity of an impulsive noise, refer the problem to acoustic engineers or to noise specialists.

The **duration** of a noise can be measured with recording equipment, a timer, or a stop watch. Impulsive-type noises can be expected to be less than 1 millisecond – measurement would require special equipment and measurement techniques.

The **frequency** content of noise is more difficult to measure, and complex equipments are required. Subjectively, however, high-frequency content and pure tones are recognizable (assuming the observer's hearing is normal). For example, noises with high frequencies have a whine (jet aircraft), a screech (certain machinery), a clank or clink, a squeal or squeak. Pure tones can be characterized as having a squeal, squeak, whistle, whine, or ping, or simply a tone. Noises with these characteristics are more annoying and disturbing to people and, at high loudness levels, more damaging. In general, subjective evaluations are not acceptable except to support or verify objective measurements.

Measurement for the physiological attribute, for existing situations, should be taken at the expected position of the human body with respect to the noise source(s). The sound-level meter should be placed where the body or people are or will be located. When the noise source is active, several readings should be taken and averaged (see discussion in Geographical and Temporal Limitations section). For accurate and precise measurement refer to *Handbook of Noise Measurement,* by General Radio Company[8], and/or *Methods for the Measurement of Sound Pressure Levels,* by American National Standards Institute (ANSI S1.13-1971).[9]

In those situations where the noise source is in the future and thus cannot be measured directly, either:

- Measure comparable, existing situations.
- Refer to published documents containing approximate dB(A) or dB levels and durations of comparable noise sources.*
- Refer the problem to acoustic engineers or noise specialists. This alternative is especially recommended in complex situations or where large numbers of noise sources are involved.)

Finally, to measure hearing loss or hearing thresholds of an individual, an **audiometer** should be used by a trained person certified as an audiometric technician, under the supervision of a physician or an audiologist. It is important to measure an individual's hearing before he is subjected to noise sources so that a baseline audiogram can be prepared. This audiogram can then be used for future references and comparisons with later tests.

Evaluation and Interpretation of Data

The following criteria can be used to determine if the noise source will affect the body in any manner. The intensity and duration of the noise **at the body** should not exceed the values given below.

*A network that closely responds to the response of the human ear and estimates damage potential.

*These dB(A) levels may be changed to reflect different distances between the noise source and measurements by applying the rule of subtracting or adding 6dB(A) per doubling or halving of distance. For example, if the estimate is given as 90dB(A) measured at 50 feet and the actual distance between the noise source and the personnel is 100 feet, the dB(A) can be estimated to be 84dB(A). Noise sources which are "line" sources such as trains and heavy streams of traffic reduce in noise level 3dB(A) per doubling of distance.

	Intensity	Duration
Internal Bodily System	85dB(A) (6)	Any
Hearing Threshold (Continuous	80dB(A)[a]	16 hr
sound, if sound of intermittent	85dB(A)	8 hr
summation is required; use	90dB(A)	4 hr
meters especially designed for	95dB(A)	2 hr
this purpose or contact audio	100dB(A)	1 hr
engineers or sound specialists)	105dB(A)	30 min
	110dB(A)	15 min
	115dB(A)	7.5 min
	>115dB(A)	Never
Hearing Threshold[b]		1000 μsec
(Impulsive sound)	140dB (at ear)[a]	
Sleep Pattern		Any
(Causes awakening)	55-60dB(A)	Any
(Causes shift in sleep)	35-45dB(A)	Any

(a) American Conference of Government Industrial Hygienists (ACGIH), 1973.

(b) Operators of artillery and small arms can be expected to receive higher intensity levels.

If these values are exceeded, the noise source may harmfully affect the body. Should these values be exceeded in the community (even from air/surface transportation) an Environmental Impact Statement and further detailed measurements and evaluations will be required.*

Special Conditions

The most serious noise impacts on this attribute are:

- Partial hearing loss caused by artillery or small arms fire
- Partial hearing loss to operators caused by combat vehicles
- Sleep-loss to the aged and the population in general or to recuperating patients caused by high noise levels and night operations

Noise-induced hearing loss due to artillery, small arms fire, or combat vehicles is not uncommon in the Army. Military personnel exposed to these noise sources should have their hearing checked periodically.

Noise sources of any type should not be located near hospitals or homes for the aged. Night operations should be isolated from these places and from any areas where people, including military personnel, are sleeping.

*Assistance from audio engineers and audio specialists should be obtained.

Geographical and Temporal Limitations

Any activities and noise sources should be geographically located so as to minimize their impact on communities and military personnel. Isolation of the activity can be accomplished by geographic distance and/or placement within natural barriers (vegetation, hills, or mountains).

Noise sources affect people differently during the day. During the day people expect noise levels to be normal, but during the evenings when outdoor events, family activities, rest, television watching, etc., take place, noise levels are expected to be much less. At night, of course, noise sources are not expected to be active. Similarly, during weekends, noise sources should not be active.

In terms of measurement, variables should be measured or projected at various geographic distances and directions from the source until criterion values are reached to determine the extent of the noise. In addition, it is important to measure noise from transportation routes and flight patterns through communities and the base. Also, the variables should be measured at various times during the day, evening, and night to determine the worst and best noise conditions.

Mitigation of Impact

The optimal method of reducing sound level is, of course, to reduce the noise being produced by the source. Since this method can be difficult or expensive to use on existing noise sources, the techniques of isolation and insulation are often used. If these techniques fail to reduce noise levels sufficiently, then the use of ear protective devices is recommended.

To reduce noise levels at the source requires engineering solutions. These solutions may include damping, absorption, dissipation, and deflection methods. Common techniques involve constructing sound enclosures, applying mufflers, mounting noise sources on isolators, and/or using materials with damping properties. Redesigning the mechanical operation of noise sources may be necessary.

Performance specifications for noise represent a way to insure the procured item is controlled. Army-material noise emissions have been subject to the U.S.

Army Human Engineering Laboratory Standard (HEL STD S-1-63C) since 1963, but this has not been a completely effective method of controlling the source of noise for several reasons:

- Not all Army material are subject to this standard.
- It is applicable only to new categories of Army material introduced after 1963.
- Noise levels contained in the standard are not based on damage risk criteria (potential hearing loss).
- It does not apply to equipment once operational.

To overcome some of these deficiencies a U.S. Army Military Standard: Noise Limits for Army Materiel significantly changes the emphasis of noise control from object/receiver to source.[11]

When an individual is exposed to steady noise levels above 85 dBA, in spite of the efforts made to reduce noise level at the source, hearing conservation measures should be initiated.[12]

The Federal Government has promulgated three regulations that relate to controlling noise at the source. These noise regulations have been issued by the General Services Administration, the Environmental Protection Agency, and the Department of Labor.

General Services Administration. The General Services Administration issued construction-noise specifications effective July 1, 1972, for earthmoving, materials-handling, stationary, and impact equipment (see Table A-5). They require that all on-site equipment used by a contractor while under contract with the General Services Administration have A-weighted sound level requirements (dBA) measured 50 feet from the equipment. For example, a tractor, regardless of type, must not exceed 80 dBA while operating on the site at a distance of 50 feet. Noise violations result in a cancellation of the contract. Nearly all existing construction equipment exceed these levels; therefore, some type of engineering noise control will be necessary.[1]

Environmental Protection Agency. Under provisions of the Noise Control Act of 1972, the Environmental Protection Agency is required to promulgate noise-emission standards for four new product categories:

- Construction equipment
- Transportation equipment
- Motor or engine
- Electrical or electronic equipment.

In addition, all railroad and motor carriers engaged in interstate commerce will be subject to noise-emission requirements. Furthermore, any product adversely affecting the public health or welfare must be labelled with the specific sound level (see Noise Control Act

Table A-5. General Services Administration Construction-Noise Specifications

Equipment	Effective Dates	
	July 1, 1972	January 1, 1975
Earthmoving		
Front loader	79	75
Backhoes	85	75
Dozers	80	75
Tractors	80	75
Scrapers	88	80
Graders	85	75
Trucks	91	75
Pavers	89	80
Materials Handling		
Concrete mixers	85	75
Concrete pumps	82	75
Cranes	83	75
Derricks	88	75
Stationary		
Pumps	76	75
Generators	78	75
Compressors	81	75
Impact		
Pile drivers	101	95
Jack hammers	88	75
Rock drills	98	80
Pneumatic tools	86	80
Other		
Saws	78	75
Vibrators	76	75

Note: Equipment to be employed on this site shall not produce a noise level exceeding the following limits of dB(A) at a distance of 50 feet from the equipment under test in conformity with the Standards and Recommended Practices established by the Society of Automotive Engineers, Inc., including SAE Standard J 952 and SAE Recommended Practice J 184.

of 1972). Although noise-emission standards have not yet been issued, it is expected that engineering noise controls will have to be initiated.[1]

Department of Labor. Noise-exposure criteria have been established by the Department of Labor under provisions of the Occupational Safety and Health Act. To meet the provisions of this Act it requires that a hearing conservation program be initiated for protecting noise-exposed personnel and that emphasis be placed on engineering noise control. Hearing protective devices should be issued to the workers but only as an interim measure while engineering solutions are being planned.[1]

Other mitigation methods include isolation and insulation. The noise source and personnel or structures can be isolated from one another by distance.* (The intensity of noise decreases at an approximate rate of 6dB per doubling of distance.) Another method is to build barriers between the noise source and personnel, e.g., earthen barriers; walls of wood, cement, or block; or of trees and shrubs. Increasing insulation in structures will also reduce inside noise levels.

Finally the predominant method of noise control has been the use of ear-protective devices. Occupational health programs have emphasized the proper fitting and issuing of hearing protective devices** (i.e., ear plugs or ear muffs) to noise-exposed personnel as an essential ement of a hearing-conservation program. This control method has been emphasized in the U.S. Army Hearing Conservation Program as outlined in Technical Bulletin, Army Medical Department, Number 351 (TB MED 251, revised 1971), "Noise and Conservation of Hearing". The Bio-Acoustics Office, U.S. Army Environmental Hygiene Agency at Edgewood Arsenal can be of assistance in this matter.

Other Comments – (None)

Additional References

*However, facilities should not be isolated to the extent that there is difficulty in getting to the facility, or there is a possible reduction in use or usefulness of the facility.

**In situations where face-to-face communication is critical, hearing protective devices should include telephonic communication devices.

PSYCHOLOGICAL EFFECTS

Definition of the Attribute

Noise can affect an individual's **mental** stability and psychological response (annoyance, anxiety, fear, etc.).

Mental stability refers to the individual's ability to mentally function or act in a normal manner. The mental well-being of an individual is essential for personal maintenance and efficiency. It is generally agreed that noise does not cause mental illness, but may aggravate existing mental or behavioral problems.[2,6] Noise predominantly causes psychological responses and these are anger, irritability, increased nervousness, and most of all, annoyance. It is the annoyance reaction which can cause individual and community outcry and lawsuits against noise sources such as airports, aircraft, and highway transportation.

Army Activities That Affect the Environment

Most Army activities can cause annoying and unacceptable noise. The most serious are:

- *Construction.* Construction projects create noise through the use of vehicles, construction equipment, and power tools. The noise affects operators, personnel, and communities near the site, and those people near transportation routes to the site.
- *Operation, Maintenance, and Repair.* The operation of all types of air/surface vehicles, machinery, power-generating equipment, and weapons will generate noise. Maintenance and repair produce noise through the use of all types of tools, and when a number of noise sources are operating at the same time in the same general areas (e.g., a vehicle repair shop).
- *Training.* Training courses and exercises which use any type of vehicle, weapon, power tools, appliances, machinery, create noise for operators, military and civilian personnel, and, in large-scale exercises, can affect nearby civilian communities.
- *Industrial Plants.* The machinery and tools contained in these plants are a significant source of noise to the personnel and, if noise levels are sufficiently high, can affect nearby communities.

- *Research, Development, Testing, and Evaluation.* These types of facilities contain noise sources which could affect both personnel and communities. Examples include wind tunnels, machinery, experimental apparatus, and the testing of weapons, air/surface vehicles, and engines.

Source of Effects

The sources of noise which affect this attribute include:

- *Weapons.* Missiles and artillery, including small arms, have extremely high noise levels which can disturb and annoy personnel and nearby communities.
- *Vehicles.* Both combat and noncombat vehicles, in the air, on the ground, or on water are significant sources of noise which annoy and disturb operators, base personnel, and nearby communities. In particular, aircraft around military bases to a high degree can disturb and annoy base personnel and communities. Some individuals living directly beneath flight paths experience anxiety and fear from the aircraft noise.Others, particularly base personnel, find they must stop their work and mental processes due to a passing aircraft which in turn produces annoyance reactions.
- *Construction Equipment.* These types of equipment which include vehicles and power tools have high noise levels which annoy operators, site personnel, and nearby communities. In addition, vehicles on transportation routes to the site generate noise which affects people living along the routes.
- *Machinery.* Machinery used for fabrication or generation of power can also annoy operators, base personnel, and community citizens located near them.

Variables to be Measured

The important variables of noise, which affect this attribute, are its **loudness, duration,** and **frequency content.** As loudness and duration increase, psychological stress, annoyance, anger, and irritability also increase. In terms of frequency content, people are generally more annoyed by high frequencies and pure tones. The frequency content of a noise source also gives the sound an identity. Certain noises are annoying, disturbing, or fear-producing (to some people) because of their identity, e.g., sirens, jack hammers, horns, motorcycles, aircraft, buzzers, trucks, backfires, gunshots, and air compressors.

Noises which have very high noise levels, but very short durations (called **impulsive** noises), such as gunshots, vehicle backfires, and sonic booms, startle people. These individuals are not only annoyed, but express feelings of fear and anxiety and their activities (particularly sleep) are severely interrupted.

How Variables are Measured

The measurement of **loudness, duration, frequency content,** and **impulsivity** are discussed under Physiological Effects.

Evaluation and Interpretation of Data

It is difficult to establish a single set of criteria due to the variety of acoustical and social factors. In addition to the intensity or loudness and duration of noise, other acoustical considerations involve pattern, occurrence, and the noise source itself. Social variables such as demographic characteristics, personality type, and predisposition to nervousness must be considered.[1]

While the spectral content and temporal patterns of noise pressure levels are important, as general criteria, ambient noise levels exceeding 50 to 55 dB(A) during the day or 45 to 55 dB(A) during the night will disturb and annoy most people.*

Special Conditions

While environmental noise alone probably does not produce mental illness, the continual bombardment of noise on an already depressed or ill person cannot be helpful. Certainly it interferes with sleep, producing irritability and other tensions. Definitive research has not been done in this area, but one 1969 study in England provides strong supporting evidence. Comparative studies of persons living adjacent to London's Heathrow Airport with others living in a quieter environment revealed that among those living

*These criteria are in agreement with most zoning ordinances in the United States.

in the noisy environment there was a significantly higher rate of admission to mental hospitals.[6]

Another recent medical discovery is the effect of noise on unborn babies. Previously, they were thought to be insulated from the noise stress of the outside world, but now physicians believe that external noises can trigger changes in fetuses.[6]

Study of steelworkers indicates that those working in a noisy environment are more aggressive, distrustful, and irritable than workers in a quieter environment.[6] These studies show that it is very important to keep noise levels as low as possible in communities near hospitals, mental houses, homes for the aged, and any place where people may be particularly annoyed or placed under mental stress by noise.

Geographical and Temporal Limitations

See discussion under Physiological Effects.

Mitigation of Impact

Mitigation procedures relevant to the attribute are discussed under Physiological Effects.

Other Comments – (None)

Additional References

COMMUNICATION EFFECTS

Definition of the Attributes

Noise can affect **face-to-face** and **telephonic** communication and, during extreme high levels of intensity, visual impairment has been reported.

Aural **face-to-face communication**, or the ability to give and receive information, signals, messages or commands, without instrumentation, is an essential Army activity. The temporary interference or interruption of communication during phases of human activity can be annoying, and occasionally hazardous, to personal well-being. Interference occurs when the background or ambient noise levels of the environment are of sufficient intensity to mask speech, making it inaudible or unintelligible. Noise that interferes with communication can be dangerous, particularly when a message intended to alert a person to danger is masked, or when a command is not heard or understood. More commonly, however, noise is annoying because it disrupts the communication process.*[1-3]

Telephonic communication, or the ability to give and receive information through telephones, headsets, receivers, etc., is also an important Army activity. Noise affects this type of communication in the same way as face-to-face, i.e., it causes annoyance and disruption. However, due to the insulation effect of the telephone or headsets and control over the volume of the incoming or outgoing signals, higher levels of loudness or intensity can be tolerated.[1]

Army Activities That Affect the Attribute

Most Army activities generate noise sufficient to interfere with aural communication:

- *Construction*. Construction projects create noise through the use of vehicles, construction equipment, and power tools. Noise levels are high enough to impact all types of communication, particularly for the operator and personnel in the general construction area.

*One of the largest complaints in the community is that noise sources disrupt TV and radio listening.

- *Operation, Maintenance, and Repair.* The operation of all types of vehicles, machinery, and weapons will create noise at such levels to interfere with communication of operators, and military and civilian personnel in the area and communities. Communication in and near operating maintenance and repair shops will also be affected by the noise generated by tools and vehicles.
- *Training.* Training exercises that use vehicles, weapons, and machinery create noise levels sufficient to interfere with communication between military personnel.
- *Industrial Plant.* Machinery and power tools contained in these plants are a significant source of noise and affect communication within the plant.
- *Research, Development, Testing, and Evaluation.* These types of facilities contain noise sources which can affect communication. Examples include wind tunnels, machinery, experimental apparatus, and the testing of weapons, air/surface vehicles, engines, etc.

Sources of Effects

The sources of noise which affect this attribute include:

- *Weapons.* Weapons of all types (including small arms) have extremely high noise levels and can interrupt face-to-face communication. During large-scale activities, even telephonic communication can become difficult. Weapons achieve noise levels which may be sufficient to momentarily distort vision.
- *Vehicles.* Combat and noncombat vehicles, in the air, on the ground, or on water are important noise sources that affect the communication of operators and in the community. Examples include:
  - aircraft on and around military air bases significantly affect communication; particularly in airport operations and in community areas directly beneath flight paths
  - combat vehicles generate very high noise levels and can affect communication between the operators and other personnel in operating areas
  - noncombat vehicles, particularly when operating in groups, affect communication near highways and other routes.
- *Construction Equipment.* These equipment also have high noise levels and affect the intelligibility of communication at the construction site. Transportation or routes to the site may also generate noise levels that interfere with communication near the routes.
- *Machinery.* Machinery located in industrial plants where many are operating continuously can severely affect communication within the plant.

Variables to be Measured

The important variables of noise, which affects face-to-face communication, are **loudness** of the ambient noise level and the **distance** between the speaker and the listener. As the loudness increases, masking of the speech increases, and speech intelligibility and discriminability decrease. Also as the distance between the speaker and listener increases, speech becomes more difficult to hear and to understand.

In telephonic communication, the noise variable of concern is the **loudness** of the background noise level.

As these variables increase, the speaker raises his voice to overcome the masking. Of course, the voice reaches a point where it strains and cannot overcome masking, and communication becomes impossible. In addition, the strain of shouting – and of trying to hear – is both fatiguing and frustrating in any situation, and may lead to inefficiency.[2]

How Variables are Measured

The variable **loudness** can be measured or projected in dB(A) units as specified in the Physiological Effects section. The distance between the speaker and receiver should be measured in feet.

Evaluation and Interpretation of Data

The impact of noise on face-to-face communication can be evaluated by using the chart in Figure A-6. Enter the side of the chart at the expected dB(A) noise level and bottom at the expected average

distance between speaker and listener. If the intersection of the two values falls above the Area of Nearly Normal Speech Communication, then speech communication is being adversely affected.

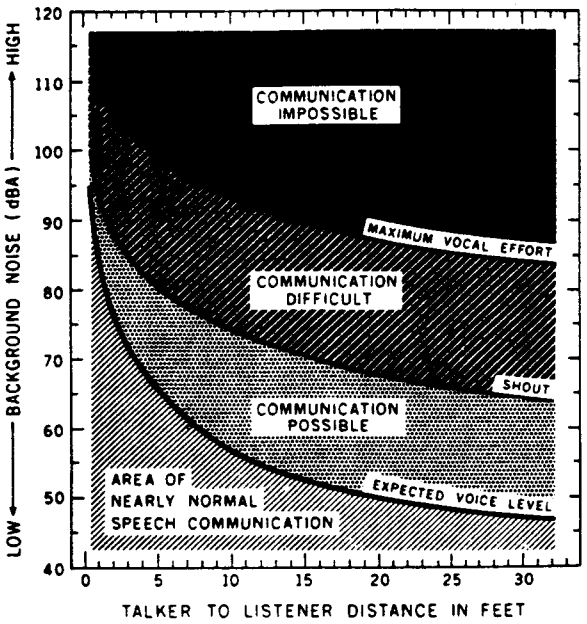

Figure A-6. Simplified Chart That Shows the Quality of Speech Communication in Relation to Sound Level of Noise (dBA) and the Distance Between the Speaker and the Listener[2]

In one-to-one personal conversation the distance from speaker to listener is usually about 5 feet and nearby normal speech communication can proceed in noise levels as high as 66 dB(A). Many conversations involve groups; for this situation, distances of 5 to 12 feet are common and the intensity level of the background noise should be less than 50 to 60 dB(A). At public meetings, outdoor training sessions, or at construction sites distances between speaker and listener are often about 12 to 30 feet, and the sound level of the background noise should be kept below 45 to 55 dB(A) if nearby normal speech communication is to be possible.[2]

In telephonic communication, background intensity levels above 65 dB become increasingly intrusive (see Figure A-7).

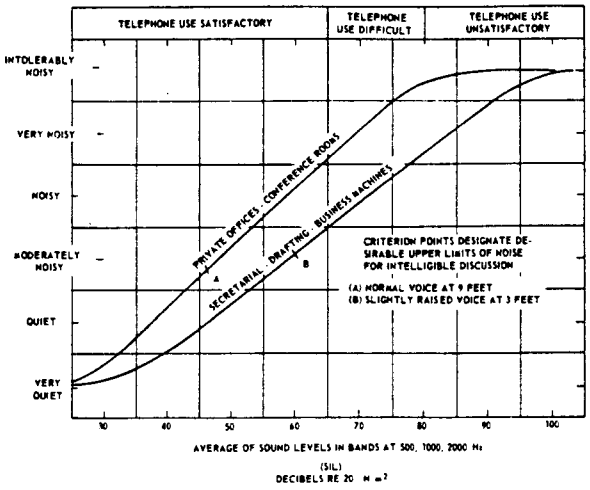

Figure A-7. Rating Chart for Office Noises[8]

Data were determined by an octave-band analysis and correlated with subjective tests.

Special Conditions

There are special areas where communication takes place which should not be disturbed. These areas include training and testing areas, schools*, churches, libraries, theaters, military communications centers, offices, hospitals, and research laboratories. Noise sources including air and land-transportation routes should be isolated from these communication-sensitive areas or the areas should be well-insulated against external noise.

Geographical and Temporal Limitations

See discussion under Physiological Effects.

Mitigation of Impacts

To insure intelligible communication, the noise sources and the personnel need to be isolated or insulated from one another. The special areas (see Special Conditions) where communication is especially sensitive should be well-isolated and -insulated against external noise.

*Schools have reported up to 60 significant interruptions per day resulting from aircraft. Some schools have been closed due to extensive noise.[3]

When it is unavoidable to have personnel who must communicate near high noise levels, communication devices should be used (e.g., headsets, field telephones).

For fuller discussion of mitigation techniques see discussion under Physiological Effects.

Other Comments – (None)

Additional References

PERFORMANCE EFFECTS

Definition of the Attribute

Noise can affect the ability of the human to perform **mechanical** and **mental** tasks. Noise can adversely affect performance through:

- The increase in muscular tension that can interfere with movement
- The lapse in attention or a diversion of attention from the task at hand
- The masking of needed auditory signals
- The startle response to high-intensity noises.

Mechanical tasks can range from simple mechanical assembly to more complex tasks. Lower order tasks such as mechanical assembly or manual routine-type activity are least influenced (if affected at all) by noise. However, tasks of this nature are altered in three essential ways by high-intensity noise. Although work output remains fairly constant[2], worker errors can increase[2], judgment of time intervals can become distorted, and a greater effort is necessary to remain alert.[1,4] Noise is most likely to affect the performance of tasks which are quite demanding and/or require constant alertness.[3]

Mental tasks such as problem solving and creative thinking are more affected by noise. Higher order tasks requiring greater mental faculties (although dependent on the individual) are generally disrupted by lower noise intensities than mechanical tasks. It is important, therefore, to keep noise at a minimum in and near office areas.[3]

When a task (mental or mechanical) requires the use of auditory signals, speech or nonspeech noise at any intensity level sufficient to mask or interfere with the perception of these signals will interfere with the performance of task.[2]

Army Activities That Affect the Attribute

The most important Army activities that can reach noise levels sufficient to affect performance are:

- *Construction*. Construction projects create noise through the use of vehicles, construction equipment, and power tools. The noise levels are certainly high enough to affect mental tasks. The mechanical tasks at the site

are generally considered highly physical and probably would be unaffected by the noise levels.

- *Operation, Maintenance, and Repair.* The operation of all types of vehicles, machinery, and weapons will create noise levels sufficient to affect human performance, primarily through distraction.
- *Training.* Training exercises which use vehicles, weapons, and machinery create noise levels high enough to distract people.
- *Industrial Plants.* Machinery and power tools contained in these plants are a significant source of noise which affects mental and mechanical performance.
- *Research, Development, Testing, and Evaluation.* These types of facilities contain noise sources that can affect performance. Examples include: wind tunnels, machinery, experimental apparatus, and testing of weapons, air/surface vehicles, and engines.

Source of Effects

The sources of noise that can affect performance include:

- *Weapons.* Weapons of all types generate noise levels which can interfere and interrupt mental and complex, precise mechanical tasks.
- *Vehicles.* Vehicles of all types are significant noise sources which can interfere and interrupt task performance. In particular, military aircraft can disrupt the mental tasks of large segments of personnel on bases and in communities.
- *Machinery.* Machinery and power tools in industrial areas create high noise levels that could affect some complex and precise mechanical tasks.
- *Construction Equipment.* Noise from these equipments can affect the mental tasks of personnel in the area.

Variables to be Measured

The important variable of noise which affects task performance is **loudness.** As the loudness of noise increases, the effects of the noise on performance increase. First, mental tasks are affected, then as the loudness further increases, complex and precise mechanical tasks become affected.

How Variables are Measured

Loudness of noise is measured in terms of decibels. A detailed discussion of how to measure or project decibel levels can be found under Physiological Effects.

Evaluation and Interpretation of Data

The following criteria can be used to determine if the noise source will affect task performance. If the intensity of the noise source exceeds the values given below, task performance may be affected, depending upon the spectral content and temporal patterns of the noise.

Task	Intensity
Mechanical, manual, or mentally repetitious	85dB(A)
Mental (Problem solving or creative)	See Table A-6

Table A-6. Noise Criteria for Mental Tasks

Type of Room	Maximum Permissible Level (measured when room is not in use)
Small Private Office	45dB
Conference Room	35dB
Secretarial Offices (Typing)	60dB
School Rooms	30dB
Reading	40dBA
Meditation	40dBA
Studying	40dBA
Individual Creative Activity	40dBA

Special Conditions

Special areas where mental tasks take place should not be disturbed. These areas include offices, conference areas, schools, indoor training areas, libraries, and research laboratories. In terms of mechanical tasks, it is difficult to be specific. Wherever complex, precise, and demanding mechanical tasks are performed, the environment should be protected from high-intensity-noise sources.

Geographical and Temporal Limitations

See discussion under Physiological Effects.

Mitigation of Impact

The optimal method of reducing sound levels is through noise source reduction, isolation, or insulation. Methods of achieving noise reduction are discussed under Physiological Effects.

Other Comments – (None)

Additional References

SOCIAL BEHAVIOR EFFECTS

Definition of the Attribute

Social behavior refers to the individual's ability to mentally function in a normal manner on an interpersonal basis. Under certain conditions within communities, interpersonal relationships are altered when noise is of sufficient intensity. Areas of socialization may become restricted due to noise exposure. Outdoor areas are first to be affected, thus limiting socialization to residential interiors. Patterns of entertainment become confined and restricted. When one or more methods of basic auditory communication (face-to-face or telephonic) are masked, the channels for social interaction become limited. These results, in turn, affect personal attitudes and create annoyance.

Army Activities That Affect the Attribute

Most Army activities generate noise levels which could interfere with social behavior.

- *Construction.* Construction projects generate sufficient noise to interfere with the social behavior of personnel and communities located near the site. In particular, new transportation routes to the site will introduce new noise levels to people living nearby which in turn can adversely affect social behavior.
- *Operation, Maintenance, and Repair.* The operation of air/surface vehicles and weapons increases the noise level of the outside environment where much socialization takes place. Social behavior inside structures can also be affected by these activities, if their noise levels are extreme.
- *Training.* Training exercises which use vehicles, weapons, and machinery create noise levels sufficient to interfere with socialization between personnel. Noise from large-scale training exercises can also affect the community.
- *Industrial plant.* Machinery and activities in the plant are a significant source of noise which affect social behavior between personnel and in nearby communities.

- *Research, Development, Testing, and Evaluation.* These types of facilities contain noise sources which can affect socialization. Examples include wind tunnels, machinery, experimental apparatus, and testing of weapons, air/surface vehicles, and engines.

Source of Effects

Most Army-generated noise sources are capable of influencing social behavior in community environments, particularly outdoors. In and around military air bases, weapons, construction equipment, aircraft, helicopters, and ground-transportation vehicles generate noise levels sufficient to interfere with interpersonal communication, thus affecting and limiting social behavior on the base and in surrounding communities. Social behavior inside structures is probably affected mostly by machines, heating and air-conditioning units, operating appliances, research equipment, or external noise sources with very high levels such as aircraft, trucks, and construction equipment.

Variables to be Measured

The important variables affecting this attribute are the same as those discussed under Communication Effects. As communication becomes difficult or impossible, social behavior and interpersonal relationships become limited, especially in the outdoor environment.

How Variables are Measured

See discussion under Communication Effects and Physiological Effects.

Evaluation and Interpretation of Data

Evaluation techniques, as outlined under Communication Effects and Psychological Effects, should be applied to this attribute for both outdoor and indoor environments.

Special Conditions

Social behavior is important to people. Being able to socialize with friends, neighbors, and members of the family is an essential human activity. Constant interruption of these activities can only result in frustration and annoyance. Consequently, it is important to consider the impact of continuous or highly repetitive noise sources such as aircraft, weapons, and vehicles on social behavior on-base and in the surrounding communities.

Geographical and Temporal Limitation

Socialization is normally expected to take place in the community, and in and around living and entertainment areas. These areas then should be measured (inside and out) to determine if any noise sources are affecting social behaviors. One of the most prevalent noise sources is from transportation, both from routes through communities and flight paths. These, too, must be measured.

Socialization occurs most often in the evening early night hours and on weekends. Measurement of noise during these periods should be emphasized for this attribute.

Mitigation of Impact

Social behavior is primarily affected by noise sources which create high noise levels in the outdoor environment. The mitigation techniques of source control, isolation of the sources from the community or creation of barriers would be useful. Discussion of these techniques is found under Physiological Effects.

Other Comments – (None)

Additional References

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(11) U.S. Army Military Standard, *Noise Limits for Army Materiel,* MIL-STD-1474 (MI), 1 March 1973.

(12) *Noise and Conservation of Hearing,* U.S. Army, Technical Bulletin Med. 251, March 1972.

SOCIOECONOMIC ATTRIBUTES

Socioeconomic impacts are considered because the Army is concerned with the environmental consequences (biophysical aspects) caused by socioeconomic changes resulting from Army actions. However, in order to determine these secondary impacts, the primary social and economic changes which induced them must first be evaluated.

In the case of social changes, for example, there may be environmental effects on air, water, land, etc., from increasing or decreasing the population in an area. Additional people cause increased demand for water, sewage treatment and power; they require new housing which takes land for new developments, shopping centers and schools; they require transportation which increase traffic congestion and degrades air quality.

In the case of economic effects, for example, programs or actions that add or reduce revenue at an installation will result in additional or decreased population and new economic activity in local communities. This may take the form of new or fewer retail outlets (stores, garages, etc.), increased or decreased service-oriented businesses, and land-use changes as new home developments, shopping centers, etc., are created or requirements for them are reduced. Most of these activities, even though they take place outside the installation, will have an impact on air, water, and land, and stem from the Army-induced economic changes.

These socioeconomic changes frequently may result in secondary or indirect impacts on the biophysical environment. These impacts need to be identified and assessed, and it is in that context that the socioeconomic attributes need to be examined and evaluated for change.

A critical aspect of man's environment is characterized by the way in which man interacts with other men and the natural environment. Owing to the complexity of his activities and interrelationships, it is difficult to identify general parameters that describe the condition of human resources. The attributes that have been identified for this purpose are obviously not completely descriptive of all man's activities and may appear to miss many important issues. Because of their generality, the attributes also are difficult to measure and define. As a general rule an adequate assessment of impact on human resources will probably have to be undertaken by persons with special expertise in this area (sociologists or psychologists). The attributes that should be examined include:

- Life styles
- Psychological needs
- Physiological needs
- Community needs.

The potential impact on the economic structure from changes in Army activities stems primarily from the direct effect of purchases of services and material and the indirect effects arising from military payrolls. These effects may be summarized by reference to three major attributes that reflect impact on industrial and commercial activities, the local government, and the individual. These attributes are as follows:

- Regional economic stability
- Public sector revenue
- Consumption per capita.

LIFE STYLES

Definition of the Attributes

This attribute refers to the many social activities of man. Such activities often take on structural characteristics which eventually cause them to be organizations. The makeup of organizations may vary, depending upon the characteristics, interests, and objectives of the organization population. Some bases for these organizations could be racial, ethnic, political, religious, and occupational. Another perspective of this attribute occurs in the form of informal interaction between friends, relatives, and coworkers.

Army Activities That Affect the Attributes

The major classifications of Army activities affecting this attribute include construction, training, mission change, and real estate. A number of minor activities falling within these major categories could affect this attribute.

Source of Effects

Change or impacts that occur in this attribute will be dependent upon changes that occur in the population. For example, on an Army base where various activities have been established, the outmigration of a large portion of those living on the base could disrupt a number of both formal and informal activities. Examples of some of these activities are athletic groups, schools, and church groups. Individual, informal interactions are also to be considered in this attribute.

The following example is given to illustrate how a significant change in population can cause changes in this attribute. If the population were predominantly elderly people, the type of activities that they would be involved in might include hobby clubs, craft clubs, and card-playing clubs. If a large portion of this population were to migrate out of the area the stability of some of these activities might be affected. Likewise, if many more people of the same age group with the same interests moved into the community, the stability of these groups might be strengthened. Also, if the population mix were changed significantly, perhaps by an influx of many more younger people, the stability of such groups may be threatened.

Young families with growing children often serve as the predominant contributors to such group activities. When families at an Army base are predominantly in this phase of life, most of the activities on the base may be dependent upon their age group. Therefore, if a large number of these families moved off the base, the remaining families in this age category might find that groups and activities of interest are no longer functioning as before.

Variables to be Measured

The variables to be measured for this attribute cannot be precisely identified. The purpose in considering this attribute is to identify those instances in which a noticeable change will occur that will affect many people. The objective in considering this attribute is to identify general changes in social activities and practices which will be caused by the proposed Army action.

How Variables are Measured

The variables in this attribute cannot be precisely measured. One approach that can be taken to "measure" changes in this attribute would include making a survey of the area to determine the number and kinds of social organizations and activities that exist before the proposed Army action takes place. Then, having determined the changes expected to occur in the population and the characteristics of that population, impacts on organizations and activities can be predicted in terms of how they may grow, desist, or experience noticeable alterations.

Some persons who might be good sources for predicting and interpreting impacts in this attribute are leaders and participants in the organizations, coaches or local athletic teams, social and recreation leaders for the Army base, and local political leaders.

Evaluation and Interpretation of Data

Interpretation of the impacts or changes in this attribute must be performed by the impact assessment analyzed in conjunction with the opinions and assessment of the people mentioned above.

Special Conditions – (None)

Geographical and Temporal Limitations

Usually, a geographic area larger than that of the Army base (for example) must be included in the analysis, because impacts often occur outside of the base following changes within the base. The residence and work locations of those who take part in the activities that are considered a part of this attribute must be included in the geographic area.

The analysis should include a summarization of this attribute before the proposed action takes place and the anticipated changes that will result from the proposed activity. In addition to these considerations, to get a more realistic view of the total impacts, consideration must be given to what the condition of this attribute would be if the present situation, or the before situation, were to continue and what changes would occur normally without the proposed action.

Mitigation of Impact

Although impacts to this attribute cannot be completely mitigated (with the exception of postponing the proposed action indefinitely), the effect of anticipated impacts could be lessened simply by forewarning participants that such changes are expected to occur. This will enable the organizations and participants of informal activities to prepare themselves to adjust to expected impacts.

Other Comments – (None)

Additional References

PSYCHOLOGICAL NEEDS

Definition of Attributes

This attribute refers to the needs of human beings that can be distinguished from the physiological needs, primarily those of emotional stability and security. Although this attribute could relate to such factors as instincts, learning processes, motivation, and behavior, these factors are not included in this attribute because of the difficulty in relating changes in outside factors to changes in these factors. Emotional stability and security are, therefore, the only two psychological needs that are considered in this attribute.

Army Activities That Affect the Attribute

The major classifications of Army activities that are likely to affect this attribute are construction, training, mission change, and real estate.

Source of Effects

Changes in the degree of emotional stability and feelings of security within the individuals affected could occur from a number of Army activities. For example, in construction or real-estate activities, it may be necessary for some people to be moved from their homes or businesses. Even though it is difficult to anticipate the effect of such relocation, experience has shown that such activities may have negative effects on the people involved. These effects will vary in their degree of permanency.

Also when the proposed Army activity would involve increasing or decreasing the number of jobs in an area, it can be assumed that such activities will either increase or decrease feelings of security, particularly for those who are directly affected by the change in job availability.

Variables to be Measured– (None)

How Variables are Measured– (See next paragraph)

Evaluation and Interpretation of Data

Data concerning impacts of this attribute must be obtained from several sources. One source would be detailed plans of the proposed activities and identification of groups who might be affected in such ways as in the examples above. This information could then be given to psychologists (either civilian or Army) who could best anticipate and interpret such changes that will occur as a result of the proposed activity. Impacts in this attribute cannot be measured, other then being identified as to their potential occurrence as to whether their impacts are potentially beneficial or disruptive.

Special Conditions – (None)

Geographical and Temporal Limitations

The geographic area for this attribute must be that which contains people who would be affected by it. This, therefore, could include areas on a base and off a base.

The time limits for this attribute would be the same as for the other attributes in this section. The "before" time period should be that time shortly before instigation of the proposed Army activity. The "after" time period should be that time immediately after the proposed activity has been completed.

Mitigation of Impact

Some adverse impacts might be averted by including in the proposed activity funds and an action plan that would permit assistance for those people who would be impacted. For example, when a number of jobs are to be disbanded, a service could be set up in which those people who would be without jobs could obtain assistance in locating jobs in other areas. In problems caused by relocation, some program of assistance could be instituted in which people could be aided in finding housing and business locations similar to what they now have.

Other Comments

Even though impacts which may occur in this attribute are difficult to identify, measure, and evaluate, the attribute is included in the impact assessment process because it is very important. Therefore, it is necessary to attempt to identify situations where such impacts might occur, even if only the possibility of potential impacts can be identified with very little interpretation or evaluation. This attribute is useful, at least in trying to anticipate where impacts may occur and in identifying situations for which mitigation procedures may have to be planned for and included in the proposed activity.

Additional References

PHYSIOLOGICAL SYSTEMS

Definition of the Attribute

This attribute refers to anything that is a part of a person's body or that plays a part in a bodily function. It includes both individual parts or organs and systems, such as the transport, respiratory, circulatory, digestive, skeletal, and excretory systems. All parts of the human body that contribute to its effective, efficient functioning are included in this attribute.

Army Activities That Affect the Attribute

The major classifications of Army activities that can affect this attribute include construction; operations, maintenance, and repair; training; mission change; industrial; and research, development, testing, and evaluation. Any activity that can harm or threaten the efficient functioning of any part of the human body must be considered in light of its effect on this attribute.

Source of Effects

The possible sources of impacts in this attribute are many. They range from activities that are performed in a laboratory to construction activities that might impair the safety of individuals working in the area. This attribute considers any hazards that may impair the safety of any individual.

Variables to be Measured

There is not a list of variables that can be measured for this attribute. The purpose of this attribute is to identify potential sources of harm to people. Therefore, detailed activities and implications of the proposed Army activity must be examined to determine if any of those activities may be potentially harmful.

How Variables are Measured

It would be helpful to rely upon the knowledge and skills of people who are familiar with the kinds of harm that can occur and are considered in this attribute. It is suggested that physicians be contacted and given a description of the proposed activity. The seriousness of the potential impacts can then be determined through professional opinion.

Evaluation and Interpretation of Data — (See above section)

Special Conditions

It must be determined how many persons will be affected by the expected impacts. Although the impacts are not considered slight if they affect only a few, it may be said that seriousness will increase as the number of affected people increases.

Geographical and Temporal Limitations — (None)

Mitigation of Impact

Anticipated impacts in this attribute can be mitigated by taking whatever precautionary measures are necessary to avoid the impact. This may take the form of including in the proposed activity specific safety practices and protective devices.

Other Comments — (None)

Additional References

COMMUNITY NEEDS

Definition of the Attribute

This attribute refers to some of the many services that a community requires. It includes such things as housing; water supply; sewage disposal facilities; utilities such as gas, electricity, and telephone; recreational facilities; and police and fire protection. The nature of change or impact that occurs in this attribute as a result of the proposed Army activity will be very much dependent upon the type of change that is expected to occur in the population as a result of this proposed activity.

Army Activities That Affect the Attribute

The major classifications of Army activities that are likely to affect this attribute are construction, training, mission change, real estate, procurement, and administration.

Course of Effects

As changes in population and characteristics of the population occur, so also will the needs or services required for that population change. For example, in the general activity category of construction, a temporary force of construction workers may be required to perform the activity. If the construction workers and their families must settle in an area until the construction is completed, these workers and their families will require particular services such as those mentioned in this attribute. Likewise, when they leave the community, the demand for these services will have been lessened or perhaps even dissolved, thus, leaving the community with a supply of services that is no longer needed.

Also, in the activities of training, or mission change, a number of people may be brought into an area on a permanent basis, and the community, whether military or civilian, may find itself unprepared to provide the services and needs to this permanent addition to the population. Also, impacts can occur as a result of a change in mission or a change in the number of training activities taking place on a particular base. These impacts may result from fewer numbers of people requiring the services that have already been designed to serve a greater number of people. For example, a community might find itself with an oversupply of houses or have to decrease the number of personnel required for such activities as police and fire protection.

In the activities of real estate, procurement, and administration, there are particular subactivities that relate directly to the provision of some of these services. Therefore, any proposed activity that has to do with the provision of such services should be investigated as to the impact that will occur.

Variables to be Measured

For the impact-assessment procedure, variables that should be measured are those which will indicate services in the community, both military and civilian, that are available and what services are needed. Both military and civilian communities should be surveyed in order to determine (1) the change in population and the characteristics of that population (2) the number of houses and apartments that are available to meet the needs of the population if there will be an increase, (3) the number of homes that are supplied with water and sewage-disposal facilities and other utilities, (4) the number of personnel on the police force and the fire department, and (5) the number of acres of land devoted to recreational activities and the number of recreational activities available in the area.

How Variables are Measured

The military and civilian communities should be surveyed to determine what services are now available. For example, a survey should be made to determine the number of available dwelling units (houses, apartments, and trailers for example) that are available and the number of those served with adequate water, sewage, and utility service. The availability of recreational facilities can be determined by noting the number of acres devoted to recreational usage and the number of recreational activities available. The number of police and fire protection personnel should be determined to indicate the level of service now available to the population.

Various sources can be utilized for obtaining this information. Civilian planning agencies often have information on all of these services. Police and fire department personnel are sources which can give an indication of the adequacy of these kinds of services. Army-based personnel can be used to determine adequacy of base housing and base service.

After this information is obtained, it will be necessary to relate the present conditions to the change in population that is anticipated from the proposed Army activity. If the population will increase, it must be determined if there are enough facilities and services available to serve the incoming population. On the other hand, if there will be a decrease in population or an outmigration, the services provided by both the military and civilian communities must be considered in light of the oncoming decrease in demand. Perhaps other uses can be made of these services that will no longer be in demand in their usual manner.

Evaluation and Interpretation of Data

There are no standardized means of interpreting the above-mentioned variables. For the purposes of an impact assessment, when anticipated changes in population of an area will cause serious problems in the services needed by the population, the situation must be further studied for the impact statement. The above-mentioned personnel can be useful in determining when a serious problem will exist, given an immigration or outmigration of a significant number of people in the community.

Special Conditions – (None)

Geographical and Temporal Limitations

The geographic area to be considered in this attribute will vary depending upon the proposed Army activity. The area to be considered will depend upon where the affected population reside and work. Therefore, any areas, military and civilian, where people who will be affected by the services discussed herein reside or work must be considered in the determination of impact.

In determining the impact that occurs within this attribute, the analysis must be done for the area before and after the proposed activity is instituted. It is suggested that the "before" time period incorporate those conditions that exist or can be anticipated to exist shortly before the proposed activity is instituted. It is also suggested that the "after" time period be that time shortly after the proposed activity has been completed.

Mitigation of Impacts

Impacts in this attribute can be mitigated by including in the planning process for the proposed activity a plan for providing the services that have been identified as being needed, or proposed alternative uses that can be made of services that will no longer be needed as such by the population.

Other Comments – (None)

Additional References

REGIONAL ECONOMIC STABILITY

Definition of the Attribute

This attribute indicates a change in the ability of a region's economy to withstand severe fluctuations, or the speed and ease an economy demonstrates in returning to an equilibrium situation after receiving a shock. This is an **ex post** definition, whereas a surrogate, **ex ante** definition is the diversity of a regional economy or the degree of homogeneity of the region's economic activities in contributing to the gross regional product. The more diverse an economy and the more closely related it is to growth areas of the national economy, the more stable it is likely to be.

Army Activities That Affect the Attribute

Army activity that results in some input or output relationship with a local business or individual has an impact on the growth and stability of the regional economy. Direct Army purchases would have an effect, and indirect purchases through payrolls would have an effect.

Source of Effects

The severity of a change in stability is directly proportional to the degree of dependence of the regional economy on the affected business for incomes and employment. Thus, if one or a few industries or firms dominate a region's economy (measured by the share of gross regional product or proportion of total employment), that region is highly sensitive to factors affecting those industries. Hence, Army activities that decrease the industrial diversity in an area are reducing the stability of the region, especially when the key industries are locally important and declining nationally.

Variables to be Measured

Effects on the regional economy are indicated by the percentage of total regional economic activity that is affected by the Army activity. For example, if 25 percent of all retail sales in a county stem from Army personnel purchases, significant impacts can be anticipated from a change in personnel. Likewise, the Army's direct purchase of labor or other materials from the local economy should be examined as a percentage of local economic activity.

How Variables are Measured

Considerable ingenuity must be exhibited by the individual who is measuring impact on regional economic stability. Variables to be examined would include employment in economic activity related to Army activities. Production and income variables might also be examined.

Evaluation and Interpretation of Data

There are no rules that would enable one to determine whether or not a given change is small or large. Instead, judgment must be exercised with explicit reference to the basis for judgment. This approach would enable any reviewer to evaluate the facts and, perhaps, disagree with the judgment. At least, full consideration of the issues and the rationale for a conclusion will have been given.

Special Conditions

Stability and growth are two goals of a regional economy. They are usually incompatible because in the long run some specialization is required if a growth rate higher than for the rest of the country is to be realized. Therefore, the unique or special characteristics of the regional economy must be considered. An economy with an agricultural base, for example, might be much more severely impacted by the use of agricultural land by the Army than if agricultural land were to be used in an industrial-based economy.

Geographical and Temporal Limitations

The same geographic and temporal limitations that exist for the per capita consumption attribute are applicable to this attribute.

Mitigation of Impact

Mitigation of negative effects can be achieved in one of two ways. Either increasing the demand for the output of high-growth industries in the region, or changing the distribution of demand for the output of different firms so that the resulting employment redistribution approximates more closely the situation at the national level (taking into account the potential for regional specialization).

Other Comments – (None)

Additional References

PUBLIC SECTOR REVENUE AND EXPENDITURES

Definition of the Attribute

This attribute is the annual per capita revenues and expenditures of local and state governments and associated agencies in the region under study. Changes in this variable can be interpreted as a measure of the change in economic well-being of the public sector.

Army Activities That Affect the Attribute

Changes in the economic, social, or physical conditions of the area due to Army activities may result in changes in public-sector revenues and expenditures. The effects would be felt primarily through changes in military payrolls and the acquisition or release of real estate by the Army.

Source of Effects

Tax receipts are directly affected by changes in personal income. Payments from the Federal government to local governments to compensate for increased local expenses also may occur. Numerous changes in costs occur in such areas as education, transportation, public welfare, health, utilities, natural resources as the direct result of an Army activity, or indirectly through some military or nonmilitary personnel change caused by the activity.

Variables to be Measured

One measure of impact is the average annual revenues and expenditures of the relevant government and its agencies in the defined geographic region over the lifetime of the project, assuming that the project or activity has been undertaken, minus the same measure over the same time span but assuming that the activity has **not** been undertaken (and everything else the same). In lieu of the annual average, a particular year may be chosen arbitrarily and the change in annual net revenue computed for that year.

Another set of variables would be a comparison, on a function-by-function basis, of the expenditures necessary to provide adequate public services with and without the project.

How Variables are Measured

The geographic extent of the impacted public sector must be defined a priori, usually as a local (town, city, or county) or state government. The changes in revenues and expenses must then be assessed on a point-by-point basis. Tax revenue changes can be determined as described in the section on measurement of variables in the per capita consumption attribute. Local sales-tax rates should be used in lieu of state rates where pertinent, and the state or local income-tax rates should be used in place of the composite national rate as described in the per capita consumption attribute. Effective state income tax rates can be found in *State and Local Finances* in the table of "Effective Rates of State Personal Income Taxes for Selected Adjusted Gross Income Levels, Married Couple With Two Dependents, by State," where local rates are simply the given percentages (no deductions).[1] Corporate tax receipts for local areas are generally not important.*

The change in gasoline-tax receipts is determined by calculating the percentage change in the number of vehicles in the area, where it is assumed that the two values are proportional. This implies that the tax rate, the per mile gasoline consumption for each vehicle, and the total mileage per vehicle is constant. The percentage change in vehicles is also assumed to be proportional to the change in personal income. Independent estimates may be made through interviewing automobile dealers or by multiplying population changes times a factor representing cars per capita. The preliminary value for motor fuel tax receipts can be based on figures from the *Statistical Abstract of the United States* in Table 4, "State Tax Collections and Excise Taxes, by Type of Tax – State", where the state receipts must be multiplied by some proportion to determine the local share (this proportion may depend on the gasoline sales, and, hence, indirectly the personal income in the area). Local data should replace the extrapolated state data where available. Since the gasoline-tax receipts for some future year (under the assumption that the Army activity has not been undertaken) is the basis for the measurement, tax receipts for at least 2 past years should be linearly extrapolated to arrive at the desired figure.

Changes in payments to the local government or its agencies by individuals, businesses, and the military for particular goods or services (e.g., water and other public utilities) should be included on a specific basis. Transfer payments from outside sources that are direct or indirect compensations for incurred expenses should be based on the specific changes in these costs caused by the Army activity, following standard reimbursement procedures. For example, compensation for increased educational expenses for military families is a transfer payment to the local area. Total changes in receipts from taxes, subsidies, and transfer payments due to the Army activity should be summed to arrive at an aggregate figure.

Changes in local public expenses due to the activity may be assumed to be proportional to changes in the total personal income in the area, reflecting both the number of consumers of a public good or service and the per capita level of consumption. The *Statistical Abstract of the United States* in the table of "Direct General Expenditure of State and Local Governments – State" gives figures for public-sector expenditures for $1000 of personal income. These ratios must be multiplied by the proportion of expenses accruing to the local government for each category: education, highways, and health. When available, these ratios should be calculated from local information for all types of public goods and services that change in the same proportion as total personal income. Some expenses, such as welfare payments, do not change proportionally and must be calculated through independent analyses. Among these expenditures are damages to public facilities or any other temporary or permanent costs that are identified as resulting from the Army activity but not through social or economic changes within the population.

*Where the entire state is the pertinent impact area, corporate tax revenues can be determined if it is assumed that corporate profits change in the same proportion as labor costs and production. The ratio of corporate to individual income tax receipts can be determined from the *Statistical Abstract of the United States* table of "State Tax Collections and Excise Taxes, by Type of Tax – State". Multiplying this ratio by the change in personal income calculated in the per capita consumption attribute results in an approximation of corporation taxes.

The percentage change in personal income in the impact area is determined from the per capital consumption attribute, and this proportion must be multiplied by the public-sector expenses per unit of income. The resulting figures are the changes in public expenditures if the project occurs, and summing them gives the total change in expenses.

Evaluation and Interpretation of Data

The changes in public-sector revenues and expenditures must be compared to determine whether or not there is a net deficit or gain to the public sector subsequent to the Army project. The severity of the impact (either positive or negative) would remain a matter of individual judgment.

Special Conditions

The measurement can be improved if a more accurate estimate of future revenue and expenditure levels without the project can be determined. A detailed analysis, perhaps using multiple-regression techniques, would improve these projections as well as help identify and evaluate more precisely the causal relationships between public-sector revenues and costs and the direct impacts of the proposed activity. Thus, the applicable factors to apply to the without-project cost and revenue levels in order to obtain any forecasted changes may be improved.

Geographical and Temporal Limitations

In general, the same geographic and temporal limitations that exist for the per capita consumption attribute are applicable in this measurement situation. The geographic range of local governments and civilian public agencies with respect to both the revenues and expenditures must be determined in a manner similar to an analysis of the market and supply areas of a private-sector business enterprise.

Mitigation of Impact

A negative impact can be mitigated if Army activities either reduce their costs to the local society (e.g., demands for public sector goods and services, physical or economic damages to existing infrastructure) or increase their direct or indirect payments to the local government.

Other Comments – (None)

Additional References

PER CAPITA CONSUMPTION

Definition of the Attribute

The annual per capita personal consumption of goods and services by local citizens (nonmilitary) is per capita consumption. This variable can be interpreted as a direct measure of personal economic well-being.

Army Activities That Affect the Attribute

Increases (decreases) in personnel strength, addition (reduction or deletion) of a function or task, other construction, operation and maintenance, administration, and similar Army activities all have the potential for affecting per capita consumption.

Source of Effects

A change in demand for local goods or services by the Army results in increased or decreased money available for purchase of goods and services (disposable income).As another example, disposable income and, therefore, consumption may be affected by a changed tax base resulting from military acquisition of formerly taxable land.

Variables to be Measured

The baseline measure is the average amount that will be spent in each future year throughout the life of the project by each nonmilitary citizen of the affected area for goods or services meant for personal consumption, assuming the project has **not** been undertaken. The variable indicating change is that same calculation, but under the assumption that the project or activity has been undertaken (with everything else exactly the same) minus the baseline measure.

How Variables are Measured

A simplified procedure for obtaining results is presented here; suggestions for more complete and accurate analysis are given later. It is assumed that businesses are not at full capacity, and, hence, a change in final output (in dollars) will be reflected in a change in all short-run costs (including labor wages). Assuming that there are constant returns to scale for inputs, the change is completely proportional and **output revenue** and **all costs** will change proportionately to the change in production, based on the current ratio of these values. In addition to labor costs, profits which accrue to the owners of a business may change. A determination of how a profit change affects personal income in the region must be based on an individual analysis of each business, with consideration for the amount of profit per dollar of output and the location of the owners (where the changed income of nonlocal residents is not included). Thus, a final coefficient for a particular industry is determined, showing the ratio of local personal income (wages, salaries, profits) to the dollar output of the industry.

Changes in output due to an Army activity may be approximately determined by first noting all nonmilitary industries, firms, or individuals who supply some needed input to the activity, and the amount of this input in dollars. Included as inputs are such goods and services as local raw materials for Army production activities, retail goods and services bought by Army personnel and their families, and contributions to local charities.

Changes in the inputs (which are the outputs of the supplying firms) must be calculated or estimated with as much accuracy as possible. Assuming a constant, linear production function (constant input mix), the change in a supplying firm's output can be approximated by first determining the ratio of the Army activity's current requirements for the firm's output (in dollar terms) to the current total requirements for that Army activity (which need not be measurable in dollar terms). Multiplying this ratio by the change in Army activity, the change in the firm's output is determined. This is multiplied by the previously calculated personal income/output ratio to produce the desired figure. Prices are assumed to be constant, but if a price change is expected to result from the activity, then the input-output ratio has to be recomputed based on the new price before being used. Direct civilian-employment changes, changes in the average wage rate (perhaps due to a change in the size of the Army's civilian labor force), or other changes that are directly caused by the proposed

activity should be examined. Any additional information indicating how the total civilian wage bill changes with a change in an Army activity should be used if possible. For example, business failures or disruptions caused by the Army activity and resulting in employment changes should be included. Other determinants of personal income, such as proprietor's income, dividends, interest, transfer payments, and other personal costs and revenues may be assumed to be changed in the same proportion as output revenue unless specific information indicates otherwise. Attempts should be made to assess these ratios whenever possible.

The change in nonmilitary disposable income equals the change in personal income minus the change in personal tax payments. Assuming a constant effective income-tax rate (due to small incremental changes in income), this rate times the change in personal income gives the total income tax change. The tax rate is obtained from the tables of "Effective Rates of State Personal Income Taxes for Selected Adjusted Gross Income Levels, Married Couple with Two Dependents, by State" or "Local Income Taxes, Rates, and Collections" in *State and Local Finances*. Changes in taxable property, together with the pertinent rate, give the property-tax alteration. By use of the *Statistical Abstract of the United States*, tables on "State Tax Collections and Excise Taxes, by Type of Tax – States", and "Personal Income by States", the ratio of sales-tax receipts to dollar income can be calculated for the pertinent state. Multiplying this ratio by the change in personal income (determined above) yields the change in sales tax receipts.

The change in personal consumption (nonmilitary) is determined by a rough calculation of the coefficient of consumption applied to the change in civilian disposable income. Thus, the proportion of disposable personal income spent on personal-consumption expenditures, calculated from national data if local information is missing, may be assumed to apply to local disposable income. While there may be some inherent errors, they are believed to be small enough to be nearly insignificant. The *Statistical Abstract of the United States* in the table on "Personal Income and Disposition of Income" gives the pertinent data from which the necessary coefficient can be calculated for the appropriate data (approximately 0.9 for all years). Multiplying this by the change in disposable incomes gives the change in consumption.

The most difficult data requirements involve the identification of all activities linked to the proposed Army activity through some input-output relationship, and the determination of each coefficient indicating the dollar change in the supplying firm's (or individual's) output due to a unit change in the Army activity (where this output relates to the particular activity being investigated). This information can come only from a simple economic analysis of each input source.

Evaluation and Interpretation of Data

The interpretation of these data must be based on the exercised individual judgment. Judgments regarding high or low impacts must be made by persons performing the assessment. The reason for the judgment should be stated also.

Special Conditions

The analysis can be improved if a complete input-output analysis is completed together with a detailed economic analysis of the change in personal income (and then in personal disposable income) that results from a change in the output of economic activities linked to the Army project. Where certain data are uncertain, an attempt should be made to use expected values if possible.

Geographical and Temporal Limitations

The geographic area within which the change in consumption occurs must be determined a priori. It is assumed that the labor shed for a linked activity is within the area (or at least a fixed and known proportion of the employees come from the area). Where linked activities are outside the area (and, hence, would not normally be included in the analysis), but either a fixed and known portion of its employees come from the study area or there is a secondary-linked business within the area, then efforts should be made to include the locally important effects in the analysis. The size of the area (i.e., spatial range of the

impacts) and any trade-offs with respect to distance must be determined arbitrarily.

The attribute-measurement methodology presented previously assumes an average of the total annual changes over the lifetime of the project or activity. This is an arbitrary procedure, and temporal trade-offs (time discounting) can be applied if desired. Calculations can be made for different years in the future in terms of with or without project changes, and the separate figures aggregated by first multiplying them by arbitrarily assigned normalized weights. Another simple alternative is to choose a single future year in which to compare with and without project changes, implicitly weighting all other years as zero.

Mitigation of Impact

Any detrimental impacts can be mitigated best if Army activities establish direct input-output linkages with area industries, businesses, or other economic activities and thereby encourage an inflow of money into the local economy. Leakages should also be minimized where monies flowing outside the area (or into noncivilian activities) are reduced and costs to the area are lowered (this includes opportunity costs, as when tax contributions and other transfer payments to the local economy from external sources are reduced through Army activities).

Other Comments – (None)

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(1) *State and Local Finances, Significant Features (1967 to 1972)*, Advisory Commission on Intergovernmental Relations, Washington, D. C.

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